DDICAL Union of So. Africa. Dept. Com. & Ind. LIBRARY
F. & M. B.S. Investig. Rept. APR 4 1960
#39
FISH & WILDLIFE SERVICE
ND
A
B
#39

UNION OF SOUTH AFRICA

DEPARTMENT OF COMMERCE AND INDUSTRIES

DIVISION OF FISHERIES

INVESTIGATIONAL REPORT No. 39

# THE BIOLOGY OF GUANO-PRODUCING SEA-BIRDS

## The Distribution, Abundance and Feeding Habits of the Cape Gannet, *Morus capensis*, off the South Western Coast of the Cape Province.

BY

R. W. RAND

THE GOVERNMENT PRINTER, PRETORIA
1959

G.P.-S.6616106—1959-60—1,200.

**Reprint from "Commerce & Industry".** OCTOBER, 1959

DEPARTMENT OF COMMERCE AND INDUSTRIES

# THE BIOLOGY OF GUANO-PRODUCING SEA-BIRDS

## The Distribution, Abundance and Feeding Habits of the Cape Gannet, *Morus capensis*, off the South-Western Coast of the Cape Province.

BY

R. W. RAND

INVESTIGATIONAL REPORT No. 39

Issued by the Division of Fisheries, Beach Road, Sea Point, Cape Town

Union of South Africa

Digitized by the Internet Archive
in 2025

https://archive.org/details/investigational-report-sfri-za_1959_39

# Contents.


| | | Page. |
|---|---|---|
| 1. | Summary | 5 |
| 2. | Introduction | 5 |
| 3. | Methods | 6 |
| 4. | Bionomics | 8 |
| 5. | Distribution | 9 |
| 6 | Abundance | 11 |
| 7. | General Account of the Food | 12 |
| 8. | Individual Food Items | 14 |
| 9. | Feeding-habits | 17 |
| 10. | Discussion | 20 |
| 11. | Conclusions | 21 |
| 12. | Acknowledgements | 21 |
| 13. | References | 22 |
| 14. | Appendix | 22 |


6616106—2

## 1. Summary.

1. During 1954–56 gannets were observed and hunted at sea up to ten miles off the coast between Lambert's Bay and Quoin Point; 257 gannets were collected during this investigation.

2. The adult gannet population is widely distributed off the coast of the Union of South Africa, individuals extending 100 miles off shore and moving continually about the coast at least 200 miles from their nesting places during the summer, but far more extensively during the winter. Young gannets range as far afield as the Gulf of Guinea on the west coast of Africa, and the coast of Kenya on the east.

3. It is estimated that 50,000 gannets resort to two gannetries off the south-western Cape. Over half of this number are generally on land. Counts of gannets at sea indicated a low density over a wide area and no concentrations of the birds were regularly found in any specific locality. Although they may disperse widely, some evidence suggests that most remain within reasonable distances of the islands throughout the year.

4. Gannets prey upon at least twelve different species of fish, an unknown variety of cephalopods, crustaceans and one species of polychaete.

5. Gannets weigh about 6 lb. The greatest weight of food in any stomach was 652 gm. or 1 lb. 7 oz. (1½ lb.). The mean weight of food in 200 stomachs was 148·2 gm. or about 5 ounces.

6. The principal prey according to numbers in all stomachs were maasbankers and anchovies, followed by pilchards and cephalopods. On the basis of frequency of occurrence, pilchards (35 per cent) were the most important prey, followed by cephalopods (19 per cent) and maasbankers (17 per cent). According to the compositon of food by weight, pilchards formed 51 per cent and were followed by maasbankers (20 per cent) and anchovies (12 per cent).

7. Gannets undertake feeding journeys of up to three days at least. They hunt by diving on individual prey and feed during the daytime only.

8. The average size of a meal is about 350 gm. (about 13 oz.). Most gannets appear to have only one meal per day when on a feeding tour. They do not forage every day but over a year spend about 265 days hunting for food. On this basis, the population of 50,000 gannets of the south-western Cape coast would be expected to consume about 5,200 short tons of marine food; 20 per cent of gannets eat a second time during the day, so that the total estimated consumption becomes some 6,250 tons. About 70 per cent, or 4,400 tons, would be commercially-important fish.

## 2. Introduction.

This report is the first of a series by the present writer to deal specifically with the bionomics of certain commercially-important (guano-producing) sea-birds habitually found off the coast of South Africa. It is descriptive of the distribution, abundance and feeding-habits of the Cape Gannet (*Morus capensis*) off the south-western coast of the Cape Province.

It has long been known that the food requirements of sea-birds producing guano are important in their successful commercial exploitation, when these affect the success or otherwise of nesting at the various islands where, of course, the bulk of guano is deposited. For many years personnel of the Guano Islands Administration have noted how the movements of guano-bird flocks varied with the whereabouts of small fish. Much of this data is of an unsatisfactory nature being general rather than specific, and it was not until 1952 that the Division of Fisheries commenced a routine examination of sea-bird stomachs to ascertain the true qualitative and quantitative aspects of their food in areas of intense commercial fishing. These studies originated at St. Helena Bay and were later extended to other areas—the Cape Peninsula in 1954 and South West Africa in 1957.

The present report supplements the St. Helena Bay observations by analysing the food of gannets

captured there and also near the Cape Peninsula. It also strives to place the feeding propensities of these birds in their proper perspective and suggests that many exaggerated opinions about gannet predation should be abandoned in the face of enlightened views on conservation and management of this sea-bird resource. Only basic biological data about these predators can supply the answer to many problems of their control in a changing environment.

### 3. Methods.

During the present investigation (1954–56) the food of the gannet was studied partly through an examination of stomachs and partly by observing feeding birds at sea or on the land. Limited field observations supplemented data about food in the stomachs. At one stage it was believed that by inducing gannets to disgorge their stomach contents, the capture of sea-going birds might be avoided. Because the birds eat distinctive foods, regurgitations might be a sound means of studying their diet. However, the origin of the food, whereabouts of the feeding-grounds (the mere presence of a bird in an area is not evidence that it feeds there), and the true quantities of food consumed cannot be studied by regurgitations only. Similarly, field methods without details of the contents of the stomach are alone unsuitable for a study of the total dietary (Gibb and Hartley, 1957).

The project started in June, 1954, as a special part of the bird and seal studies initiated by the Division of Fisheries. Patrol-boats of the Guano Islands Administration and the Division of Fisheries explored the coast from Lambert's Bay to Quoin Point. The collection of birds was originally designed to cover the whole of this area, but to avoid duplication of the original programme, no birds were collected by the writer in St. Helena Bay after 1954, although regular visits were made there when hunting seals. Owing to the uncertainty of weather conditions further south, cruises reached Quoin Point on only one occasion, usually stopping short at Dyer Island. Further comment about these coastal conditions are contained in another report (Rand, 1959) dealing with seals captured at the same time as the birds.

Cruises were undertaken at least twice a month. One or other of the patrol-boats searched north or south, the direction being determined by the rotation of duties in St. Helena Bay. Owing to preoccupation with sealing operations, the author could do no field work in July and August, 1955. The number of cruises through the various search areas was as follows:—

| Year. | Reference (Search) Areas.* | | | | | |
|---|---|---|---|---|---|---|
| | 1. | 2. | 3. | 4. | 5. | 6. |
| 1954..... | 4 | 10 | 5 | 6 | 5 | 4 |
| 1955..... | 3 | 8 | 18 | 18 | 2 | 1 |
| 1956..... | 1 | 11 | 24 | 13 | 3 | — |

* See Table 1.

During 1954–56, 257 gannets were collected during the two and a half years of pelagic hunting. The monthly collection of these birds is shown in Table 2 (see also Plates III and IV). Their number does not necessarily bear any relation to the statistical limits of a proper sample size but are simply the outcome of collecting opportunities.

Mature male and female gannets are indistinguishable at a distance; young birds have a distinct, grey-brown plumage. Sex discrimination is hardly practicable in the field but a broad age classification is usually possible. The monthly collection of gannets according to age and sex is given in Table 3, from which it is seen that immature birds were seldom encountered. Old (white-plumaged) birds were shot at random. No special plumage anomalies associated with age were recorded in the collection.

A single-barrelled (choke) 12-gauge shot-gun loaded with No. 5 or 6 shot ($1\frac{1}{4}$ oz. load) was used to despatch the birds. Such a weapon had certain short-comings and only on rare occasions could

more than two or three specimens be obtained from a flock that promptly escaped out of range during re-loading. Gannets were mostly shot when presenting a sure target and snap-shooting was seldom attempted because of the ease with which wounded individuals escaped. The selection of such targets was not done on humanitarian grounds only, for it was found that if birds were wounded they regurgitated their food without hesitation. When eventually despatched, these birds often had little food in their stomachs. This perhaps accounts for some of the nearly-empty stomachs of early June, 1954, before experience was gained about the peculiarities of shooting at sea. Gannets were frequently fired upon with No. 3 shot used primarily to kill seals. This coarse shot was superior to the finer ones on more than one occasion. The specimens were all retrieved from the water by means of long bamboo poles armed with hooks.

Preserved stomachs were weighed on a triple-beam balance, the contents removed and the empty stomachs weighed to determine the weight of the contents. The latter were then placed in a measuring cylinder partially filled with water and the volume of the food calculated by displacement. Less emphasis has been placed on these volumetric data than on the gravimetric ones. Items were separated, weighed and identified in a coloured dish, small fish being sorted and preserved for later identification.

While a study of bird stomachs gives much data about the nature of the food taken, unless such data are accompanied by details of the circumstances of the captures and of the number and disposition of birds in the area, it does not warrant any more than general deductions about the diet. In the opinion of the writer it does not justify dogmatic conclusions about the overall impact of birds on populations of specific prey. With this in mind, steps were taken to observe the movements and habits of the birds at sea and so accumulate some quantitative details about their presence in various parts of the range. That this was not done with a more desirable degree of completeness was due to the severe limitations of a single observer covering large areas at infrequent intervals. Attempts have been made, therefore, to incorporate other statistical observations about the number of gannets in the search areas. Where applicable, analysis of such sources of information has been judged useful in our appraisal of the food of the gannet.

The problem of counting widely-dispersed and constantly moving birds in an area limited by the speed and cruising range of the boat was never solved, and the analysis of density of gannets in a search area is correspondingly incomplete. Judgment of distance out to sea so as to fix the boundaries of a census area is difficult. True numbers of gannets could thus seldom be computed for a definite zone. Nevertheless, those birds encountered on cruises were recorded at every opportunity. They were often sighted far out to sea beyond the limits of the search areas, but owing to possible confusion with the somewhat similar-looking Black-backed Gull (*Larus dominicanus*) and various albatross, they are excluded from records of gannets passing the ship well within binocular range. It will be appreciated that if such records were included they would completely invalidate the present impressions of density in particular areas. The gannet is a fast-moving bird and records of density at particular times can be dramatically altered a short while afterwards.

Six reference areas have been selected for convenience of handling the field observations in relation to local distribution (see Table 1). The most northerly section (6), stretching from Cape Columbine to Lambert's Bay, includes most of the commercial pilchard fishing grounds of St. Helena Bay. Investigations in this area after 1954 were limited to observations only. The second area (5), extending from Cape Columbine southwards to Saldanha Bay, was the most northerly collecting area between 1955 and 1956. A large gannetry exists at Malagas Island. The third area (4), is spread along the coast between Saldanha Bay and Table Bay, and includes the three islands of Vondelings, Dassen and Robben. Another search area (3), lies between Table Bay and Cape Point. Because of its size, False Bay was ranked as a special area (2), adjoining the final one from Cape Hangklip to Dyer Island. It was customary to cruise round the Cape Peninsula to Pringle Bay, Hermanus or Gansbaai. These anchorages could often only be reached after dark.

Further information of interest to the feeding-habits study was obtained from gannets banded on Malagas, Bird and Lambert's Bay islands.

Aluminium leg-bands placed on adults and young birds gave data about movements at sea. More recently (1956) non-locking, corrosion-resistant rings were applied to adult gannets only, several of which were recovered in various parts of the search area and elsewhere along the South African coast during the 1956 phase of the investigation. It is hoped to extend this ringing to other gannet islands so that a reservoir of ringed birds can continually provide information about their coastwise dispersal.

## 4. Bionomics.

### (i) Physical Characteristics.

A knowledge of plumage colours assisted the identification of gannets at sea. Adults are large white-plumaged birds with long black-tipped wings. The head and nape of the neck are straw-coloured but the pointed tail is generally black. The eye-lids are light blue and the bill greyish-blue. Naked parts of the body such as the gape are black; there is a characteristic blue line running down the front of the tarsus and toe. Details about plumage variations such as colour of the tail have been described by Broekhuysen and Liversidge (1953), Sclater (1906) and others.

Because of its extensive range, the Cape gannet may associate with at least three other members of the family Sulidae. These species can be separated in the following way (mostly after Mackworth-Pread and Grant, 1951)*:—

(1) Head pale yellow—
  (*a*) Tail black—*capensis* (Cape gannet).
  (*b*) Tail white—*bassanus* (Northern gannet).
(2) Head brown—
  (*c*) Tail brown—*leucogaster* (Brown booby)
(3) Head white—
  (*d*) Tail brown—*dactylatra* (Masked booby).

Fledgling gannets (juveniles) have a dark grey plumage interspersed with white speckles. Varying amounts of whiteness appear on the neck. Albinos are occasionally seen in the large colonies. Older but immature gannets show a progressive loss of this dark plumage until their third or fourth summer. These birds retain some dark brown feathers on the head, rump and wing coverts. Fledglings of the three species (*capensis*, *bassanus* and *dactylatra*) are difficult to separate in the field although those of the last species are said to have pure white abdominal feathers (Sclater, 1906).

Adult gannets are about 35 inches long and have a wing span of about 52 inches. Specimens measured at sea had the following standard dimensions (cm.):—

| Range. | | Length. | Wing. | Culmen. | Tail. |
|---|---|---|---|---|---|
| Maximum | Males | 91·0 | 51·0 | 9·7 | 20·5 |
| | Females | 94·5 | 51·0 | 9·7 | 20·6 |
| Mean | Males | 88·5 | 48·0 | 9·2 | 18·9 |
| | Females | 93·0 | 47·7 | 9·1 | 19·1 |
| Minimum | Males | 86·0 | 45·0 | 8·8 | 18·0 |
| | Females | 93·0 | 47·7 | 9·1 | 19·1 |
| Number | Males | 4 | 16 | 43 | 16 |
| | Females | 5 | 26 | 51 | 30 |

Flying young are much the same size as adults. Two young birds (a male and female, respectively) captured at Cape Point in April, 1955, had measurements (cm.) of wing 45·5, 46; culmen 9·2, 8·6; tail 16, 16·5; and length 89,97.

Male gannets captured at sea reached a weight of 6 lb. 10 oz. (3,005 gm.) in June but females were heavier, weighing up to 7 lb. 4 oz. (3,291 gm.) during that month. These and other details about the weights of birds shot at sea are given in Table 3. *The arithmetical mean weight for both sexes is 5 lb. 15 oz. (2,695 gm.).* During the year the mean weight falls slightly after June but rises again in November. The lightest gannet (4 lb. 8 oz. or 2,045 gm.) was captured in June, 1954. In the case of 55 males, the standard deviation from the mean weight (92·8 oz.) was 7·5 oz., but 61 females showed a standard deviation from the mean (96·5 oz.) of 20·2 oz. Fifteen young gannets collected in April, May and June, a few days after they had left the islands, had an average weight of 6 lb. 9 oz.

* In a recent decision of the S.A.O.S. List Committee, a change of status was suggested for the taxonomic affinities of the Cape Gannet which is now considered to be a subspecies of *Morus bassanus* (Ostrich, 1958, XXIX (I), p. 24).

#### (ii) Breeding habits.

Sporadic nesting starts in late August, eggs usually being laid in September and October (until late November). Only one egg is laid and is incubated by both parents for about 43 days. If destroyed, clutches may be replaced. On Bird Island, Courtenay–Latimer (1954) found that mated birds show regular shifts of three or four days during incubation. The newly-hatched chick is guarded by one or other parent for about eight weeks. On Malagas Island, Broekhuysen and Liversidge (1955, 1956) report considerable variation in the amount of parental care at individual nests. During three and a half days of observation in 1956, these observers found that one parent was absent all the time, five were absent for periods exceeding 24 hours. Only one parent was present for the full 78½ hours.

Young chicks develop rapidly from a naked stage, acquire down and then develop true feathers by February. They are almost fully fledged in their 15th week of age and begin to leave the nesting grounds on an extended migration.

There is insufficient statistical information about the cyclic breeding behaviour of the Cape gannet but it will be assumed that adults spend at least 100 days ashore at this stage. It is unfortunate that studies of the habits of the birds have not kept pace with the pelagic investigations as many conclusions about predation rely upon knowledge of domestic habits on land as well as movements at sea.

#### (iii) Moult.

Adult gannets moult in the summer; the replacement of the old plumage is very gradual and extends into June or July by which time all new feathers have reached their normal length. Many birds may replace feathers while incubating eggs in November. Unlike the penguin, which is virtually incapacitated when replacing old plumage, the gannet is hardly affected by its moult.

From ring-returns at Bird and other islands, it is known that young gannets moult during their absence from the breeding grounds, gradually assuming the black and white adult colours but retaining traces of the dark immature plumage on the head, rump, back and wing-coverts when they return to the island in their third autumn or winter, i.e., at 24 or 26 months of age. Only one of these immature gannets was observed at sea (March).

### 5. Distribution.

(See *Plates I and II*).

#### (i) Range of the species.

Gannet colonies are established at Mercury, Ichaboe and Possession Islands off the South West African coast, and Penguin Islet (Lambert's Bay) and Malagas Island off the western Cape Province. An isolated gannetry is at Bird Island on the East coast. Gannets once nested at Hollamsbird Island but no longer do so.

Cape gannets have been reported off the coast of Africa nearly everywhere south of the equator. On the East coast they reach the Gulf of Zanzibar (Pakenham, 1936) and occasionally Mombasa (Jackson, 1938). On the West coast they have been sighted to the north throughout the Gulf of Guinea. In an authoritative account of their presence in this region, Chapin (1932) described three age classes near the mouth of the River Congo, namely young birds in dark grey plumage of their first winter, older ones in the fully-adult white plumage, and intermediates in their second year with dark brown backs and wings. The young birds greatly outnumbered the adults.

The species was positively identified near Gabon on the coast of the French Congo, but it was not till the recovery of ringed birds that the extent of their rather spectacular dispersal was fully realised. Ashton (1952) reported rings from young gannets captured as far north as Brass and Port Harcourt (Nigeria), 2,000 miles from the place of ringing (see also Serle, 1957).*

#### (ii) Extra-territorial movements.

The migratory status of the Cape gannet is almost a legend: Eden (1846) records its mass arrival at Hollamsbird Island on 2nd October but adds that the guano-collectors had previously interfered with the birds. Anderson (1872) notes how the young gannets suddenly disappear and

* This distribution is shown diagrammatically in Plate I, the area in which young birds habitually range being marked with crosses, that of older birds ruled (breeding grounds at Algoa Bay, the western Cape and South West African coast near Luderitz are shown as closed circles).

are never seen at their nesting grounds in their first year, reappearing in the "white dress" instead. He had seen them in the interval at Walvis Bay. Reichenow (1900) described how the migration reached Gabon in the west and Zanzibar in the east.

These early field observations were only recently confirmed by ringing at various islands off the Union of South Africa. In 1940, banding by Courtenay-Latimer (1954) led to the recovery of a young bird at Lambert's Bay, some 600 miles from its nest on Bird Island. Large-scale leg-banding by the Guano Islands Administration commenced in 1947 and was intensified in 1951 through the efforts of the University of Cape Town (Zoology Department) and the Cape Bird Club. Banding on a modified scale continues as a general management technique. The use and later recovery of the South African Ornithological Society's rings has emphasised how widely the gannets disperse (Ashton, 1954–57). Because of the nature of this ringing, recoveries have so far stressed the fact of a juvenile rather than an adult migration (Broekhuysen and Liversidge, 1956). Adults move widely round the coast of South Africa but they do not seem to cover areas as far afield as the young birds. Furthermore, recoveries have come from areas of dense human populations and do not necessarily give a complete picture of migration outside the Union. They nevertheless show that marked birds from the Cape disperse over the fishing grounds of Angola and elsewhere.

The exodus from the nests in March is a rapid one. By April and May most newly-fledged gannets have left Union waters (Sneyd-Taylor, 1955). This was amply confirmed during hunting at sea in 1954–56. A small number of "late chicks", however, may still be seen on the islands in June. A young gannet was once detected in this month fishing with older birds near Dyer Island, 200–400 miles from the nearest colony. Further details about the movements of ringed gannets from Malagas Island will be discussed in a separate report by a co-operating team which worked on that island from 1951 to 1956.

#### (iii) Local movements.

Over 10,000 adult gannets have been marked on Malagas Island and Lamberts' Bay Island since 1956. Twenty-five of these banded birds were recovered at sea off the Cape Peninsula, ten off the St. Helena Bay area during the present investigation. A few birds were found near Mossel Bay, Algoa Bay and further eastwards off the coast of Natal (see Plate II). From these recoveries, the gannets appeared to be more numerous in the vicinity of the Cape Peninsula than elsewhere.

#### (iv) Data from the Bird-log of R.S. *Africana II.*

The number and whereabouts of gannets and other sea-birds was noted during all cruises of R.S. *Africana II* between 1951 and 1953 by the Second-Officer, Mr. A. Thomas, who has revealed that they may move 100 miles off shore. The maximum distance that the birds were sighted each month throughout these years seldom dropped below 38 miles, and was usually between 52 and 90 miles. Even during the breeding season, the gannet moves far afield (Thomas, *in MS*).

Observations were usually confined to the routine stations A to T but were extended to other areas during 1951–53. Table 5 reveals that many gannets were at station R (near Malagas Island) and at M (near Lambert's Bay), but fewer at other stations. This is due to the continual activity of gannets arriving at and departing from their breeding places. Table 4 illustrates the fairly uniform distribution of the gannet at all the West coast stations.

Observations at stations X1 to X34 (pilchard spawning-areas search station) also showed large numbers north of St. Helena Bay in 1952.

#### Data from Pelagic Observations, 1954-56.

Gannets were present in all search areas. They were frequently sighted many miles outside the partially-deserted coastal strip through which the patrol-boats operated. The birds were essentially off-shore feeders, seldom entering bays or moving close to the land as is done by other species such as Cape cormorants. Because the gannets were hunted so near the shore, fewer were encountered than would have been the case if search routes had extended beyond ten miles out to sea.

Feeding gannets were observed south-west of Cape Point under circumstances suggesting that the continental shelf in this area is an attractive

feeding zone. Other gannets were often seen west of Cape Point or south of Cape Hangklip. Flights of the birds moving parallel to the shore were also seen near Walker Bay over ten miles from the shore. The general impression gained during these small-boat cruises was that when the gannets move rapidly southwards from Lambert's Bay or Saldanha Bay, they keep ten or more miles from the land, to disperse off the southern part of the Cape Peninsula, turning towards Danger Point and elsewhere farther east. Mr. R. Liversidge (*in litt.*) informs me that gannets near Algoa Bay tend also to disperse to the continental shelf rather than closer inshore.

#### (vi) Summary of distribution.

The adult gannet population is widely distributed off the coast of the Union of South Africa, extending 100 miles off shore and moving continually about the coast at least 200 miles from its nesting places in the summer but far more extensively in the winter.

### 6. Abundance.

#### (i) Numbers during the nesting season.

Davies (1955, 1956) has discussed various attempts to estimate the gannet populations of Malagas Island and the island at Lambert's Bay. Some 200,000 gannets were thought to feed in St. Helena Bay in 1954. They were assumed all to have come from the two islands. In 1955 this total was amended to 112,000. During November, 1956, however, aerial photographs were taken of all gannet colonies and preliminary counts made of all birds visible on enlarged prints of these photographs. The numbers of gannets on the southern islands were: Lambert's Bay, 6,200; Malagas Island, 24,500; and Bird Island, 20,600.

As the breeding season was in its early stages, these figures may represent the actual number of nests and if multiplied by two, the total number of nesting adults. But pairs of birds are not at the nest continually although they may be seen in varying numbers at different nests throughout the day.

About 30,700 adult gannets were counted at the Western Cape gannetries. One-fifth of these birds nest on Penguin Islet (Lambert's Bay), the remainder on Malagas Island (Saldanha Bay). Assuming that 25 per cent of the birds were with mates when the photographs were taken, then the total population of nesters is likely to be 49,120, or say, 50,000.

To summarise: there is theoretically always more than half the population of breeding adults on land from September till March, after which the number fluctuates considerably.

#### (ii) Seasonal fluctuations.

Gannets congregate on the islands when about to nest in late August. Breeding males hold empty nests until incubation reliefs commence. Most birds occupy old nests. Unemployed birds, such as those approaching maturity, loiter about the outskirts of the colonies. The number of these non-breeders varies as they succeed in mating and their status changes. There is always a single adult at a nest, the rotation of relief by a mated pair being relatively slow (24 to 72 hours). During the months of October to December, paired birds are seldom more than a few hours together at the nest, usually only staying there until they have relieved each other of incubation or guard duties. From January onwards, feeding the growing chick taxes the resources of both parents, who are both away from the nest for increasingly longer periods during the day. The erratic nature of changes of duties in the whole colony, gives an impresson of quite large numbers during the day, but increasingly more towards the evening.

After fledging in March, the chicks disappear and the adult birds are free to move to and from the land. In some years nearly all adults disappear from the islands during May, June and July, only a few injured birds remaining there. But this is not always the case. During a visit to Malagas Island in June, 1956, fifteen gannets were counted (about twelve gannets were counted on an aerial photograph taken on the 25th July, 1956); in June, 1957, numbers were almost as high as in the summer.

Large numbers of gannets appeared off Natal in June, 1954, and were actively feeding on migratory pilchards. In 1955, however, very few gannets were seen during the arrival of pilchards off this coast. The pilchard shoals apparently veer out to

sea and return westwards with the Agulhas current (Davies, 1956). It would appear that the adult gannet " migration " is by no means a regular one but is subject to wide variation in time and place.

On the West coast, Chapin (1932) reported gannets near the Congo River in June. He sighted none there in January and considered that they stay in the vicinity of this river from May till November. The seasonal increment of gannets up the West coast is discussed in reports by Ashton (1950–57) and Sneyd-Taylor (1955), who trace the dispersal of young birds from Bird Island.

#### Western Cape Coast.

Two gannetries exist upon the West coast of the Cape Province. It might thus be expected that more gannets are found in these waters than elsewhere along the Cape coast. This should be remembered when considering the various logs that are correlated and the results given in Tables 4 to 6.

#### (*a*) Bird-log of R.S. *Africana II.*

The routine West coast stations A to T are arranged in a rectangular area with sides 65 miles by 100 miles or roughly 6,500 square miles. From April, 1951, to March, 1953, Mr. Thomas counted birds at each station.

The average monthly numbers of gannets varied from just over 100 to nearly 2,000 (see Table 4). There was a marked upward fluctuation during the winter (May to August) but a drop in the spring and early summer (see Table 4). These figures reflect a normal fall in numbers at sea during the breeding season.

Observations at the pichard spawning search stations also indicated large numbers at sea during the winter (June to September), followed by a decided fall during October but less so for the rest of the summer and part of the autumn. In 1952 there were nearly 30 per cent juveniles among the birds counted in March, but this dropped to 1·2 per cent in June and did not exceed one per cent for the rest of the year (Thomas *in MS.*).

#### (*b*) Observations in Table Bay, 1954-55.

Mr. T. Stafford–Smith made continuous notes of gannets moving through Table Bay during 1954–55. His records confirmed the paucity of the birds in bays, but showed that numbers will move there on special occasons. The greatest number of gannets was sighted in June but fewer in July, August and September. During the late spring and summer, gannets passed through Table Bay but their numbers never reached those of June. Only 60 gannets were observed in Table Bay in January (Stafford–Smith, *in MS.*).

#### (*c*) Pelagic Investigations, 1954-56.

By taking the number of birds observed each month and dividing this by the number of observational days, a monthly figure is obtained for the number of birds per cruise irrespective of the locality. This general figure may be compared with the density figures of the bird-log of R.S. *Africana II.* The patrol-boats sighted about 25 gannets per observation day whereas the off-shore cruises of *Africana II* accounted for up to 200.

Numbers of gannets in more specific areas near the Cape Peninsula are listed in Table 6. Generally the highest numbers (over 20) per observation day were obtained in late winter and spring. Few birds appeared in the summer and autumn.

#### (iv) Summary of abundance.

Because of the constant arrival and departure of breeding birds, sight records near gannetries give an exaggerated impression of numbers at sea. For this reason more gannets are generally recorded from the inshore areas during the summer than the winter. It is estimated that 50,000 gannets resort to two gannetries off the western Cape coast. Over half of these birds are generally on land. Counts of gannets at sea indicate a low density over a wide area and no concentrations of the birds were regularly found in any specific area. Although they may disperse widely, evidence suggests that some remain within reasonable distances of the islands throughout the year (fledgling gannets migrate so rapidly that they are not considered important in the area under discussion).

## 7. General Account of the Food.

Gannets have long been known to feed on small fish. Most early descriptions of their food, however, have been uncritical. Thus Eden (1846) described how the West coast gannets feed on " small herrings; of which their skin smells strongly." Layard (1875) stated that " they visited

Table Bay in vast numbers in the month of April and May in pursuit of shoals of fish that then appear on the surface." In May and June, according to Hewitt (1931), streams of gannets follow shoals of mackerel as they pass eastward off East London.

Courtenay–Latimer (*in litt.*) collected gannets on Bird Island in 1936 and found that they had eaten French Madams (*Boopsoidea inornata*), Mullets (*Trachystoma euronotus*), Silverfish (*Rhabdosargus fasciatus*), Rattails (*Coelorhynchus fasciatus*) and Sandcords (*Gonorhynchus gonorhynchus*).

As a result of extensive collecting by patrol-boats in the St. Helena Bay area, Davies (1955, 1956) listed seven additional prey species which were also found in gannets collected round the Cape Peninsula, namely: Pilchards (*Sardinops ocellata*), Maasbankers (*Trachurus trachurus*), Mackerel (*Scomber japonicus*), Anchovies (*Engraulis japonicus*), Mullets (*Riza ramada*), Skippers (*Scomberesox saurus*) and Squid (*Loligo reynaudi*).

The present report supplements this list of prey with the following: Sandeels (*Ammodytes capensis*). Round Herrings (*Etrumeus micropus*), Needlefish (*Hyporhamphis knysnaensis* and *Hemirhamphis far*), Gurnards (*Trigla* spp.), Leerfish (*Hypacanthus amia*), Snoek (*Thyrsites atun*), Stockfish (*Merluccius capensis*), Flyingfish (*Cypsilurus furcatus*), Squid and Cuttlefish other than *Loligo reynaudi*, and crustaceans and polychaetes.

#### (i) Weight of food in stomachs.

The greatest weight of food in any stomach was 652 gm. or 1 lb. 7 oz. from St. Helena Bay in August, 1954. Other high weights were 605 gm. or 1 lb. 6 oz. from an adult male gannet caught in False Bay (March, 1956) while pilfering dead pilchards spilling out of a lampara net; and 581 gm. or 1 lb. 4 oz. from an adult male gannet caught in Camps Bay during December, 1955.

Maximum weights of food (virtually all fish) are given in Table 11 for various months of the year. The mean weight of food per bird did not exceed 14 ounces in any month. *The mean weight of food in 257 stomachs was 115·3 gm. or about 4 ounces.* (standard deviation 139·8 gm.). This corresponds to about four per cent of the average body weight (the maximum intake is about 25 per cent of the body weight).

Less food was taken in the morning than in the afternoon (Chapter 9). It was thought that this was due to the greater time available for hunting after midday but an analysis of the amounts of food taken hourly does not confirm this. One hundred and forty-three gannets shot in the morning contributed 44 per cent of the total food in all stomachs. These birds had each taken about 22 grams per hour. The other gannets (114) contributed to 56 per cent of the food but had each taken a somewhat similar average of 20 grams per hour. Some gannets can secure enough food to fill their stomachs within two hours after sunrise (the highest hourly weight of 652 grams was obtained before 0830 SAST), but this does not appear to be the general rule as stomachs also acquire high maxima in the afternoon.

#### (ii) Size of prey.

A distinct limit to the size of fish prey is imposed by the length of the stomach and oesophagus. Gannets seldom take prey which they cannot accommodate in their stomachs. The longest prey in a single stomach was a skipper of length 35 cm. or about $13\frac{1}{2}$ inches. Further details about the size of specific prey are given in Chapter 8 below.

#### (iii) Composition of food by numbers.

The major food items (freshly ingested) in 178 stomachs were counted. Maasbankers and anchovies were the principal fish food (54 per cent) with pilchards and cephalopods of lesser importance. Numerically, the prey was in a ratio of eight fish to one cephalopod.

#### (iv) Composition of food by weight.

The inclusion of relics of past " meals " may place an undue emphasis on certain items and not enough on others. In describing the contents on percentage by bulk, this error is reduced, past " meals " receiving little or no percentage value. In a large series of stomachs, present " meals " of all the important food elements would hardly be influenced by trace items.

Pilchards formed 51 per cent by weight of food in all stomachs (see Table 13). Maasbankers were 20 per cent by weight, anchovies 12 per cent and other fish of varying but lesser importance. Cephalopods were about 2 per cent by weight of all contents.

Some seasonal variations in the diet are shown in Table 10, where the per cent composition by weight of fish is compared with that of cephalopods in those stomachs (200) with appreciable quantities of food. Further details of the composition of the more important fish during the various months are shown in Table 12. Pilchards dominated the average monthly take and were exceeded by maasbankers only in December and April. Anchovies were the principal food in December (see Plate V).

Progressively more pilchards were taken in each succeeding year of the 1954–56 studies but fewer maasbankers. In fact, the latter dropped from 43 per cent in 1954 to only 5 per cent in 1956. The dearth of maasbankers was made up by the inclusion of more anchovies and mackerel in 1956 than in previous years.

The gravimetric method of describing various items in the stomachs of the gannets was preferred to a volumetric one. The chief drawback was its inability to express the importance of soft-bodied prey such as cephalopods when traces might well have been either remains of ultimate or long-past meals. It was not possible to restore prey to its original weight or volume. This volume-when-alive value was used extensively by Davies (1956) for estimating the contents of stomachs from St. Helena Bay.

#### (v) Composition of food by frequency of occurrence.

Fish were found in 213 stomachs, cephalopods in 50, crustaceans in ten and polychaetes in two. By frequency of occurrence the ratio of the main prey groups was roughly in multiples of five, thus five fish to one cephalopod, and five cephalopods to one crustacean. More stomachs (35 per cent) contained pilchards than any other items. Second in importance was the cephalopod (19 per cent), closely followed by maasbanker (17 per cent). The frequency of other major items is shown in Table 15. Unidentified fish were found in 13 per cent of stomachs.

One-third of the specimens had taken pilchards n 1954 and 1955 but more (50 per cent) had preyed on this fish in 1956. Most gannets had taken maasbankers in 1955. Seasonal variation in the take of pilchards, maasbankers and squid is shown in Tables 15 and 16 (see Plate V), from which it is seen that squid are a major food item in the early summer but pilchards are more important in the winter.

The occurrence of combinations of prey is shown in Table 17. By far the majority of stomachs with single prey contained pilchards; maasbankers were less evident.

#### (vi) Regurgitations.

When disturbed at sea or temporarily handled at their nests, gannets often regurgitate the contents of their stomachs. During bulk ringing of captured gannets, the birds frequently regurgitated fresh or easily-identifiable fish. Pilchards, maasbankers, skippers, mackerel, juvenile snoek, and flying fish have been recorded on these occasions. The fish were often fresh or only slightly digested.

#### (vii) Fluctuations in food consumption.

Most (68 per cent) empty stomachs came from August (see Table 7), but it was in July that the quantity of food per unit of body weight was lowest. This ratio was highest in April and September. While the numbers of specimens are perhaps too small to show accurate correlations, it might well be that the birds rely on accumulated fat during the winter (and so eat less), but feed heavily when the chicks disappear and when nesting recommences (see Chapter 9).

## 8. Individual Food Items.

#### (i) Fish.

Gannets took at least 15 different species of fish off the Cape Peninsula. In St. Helena Bay the birds preyed upon five species (Davies, *op. cit.*). The fish were all rather small and belonged to species well-known for their shoaling habits. It appears that the few (five) prey species in St. Helena Bay are largely offset by a variety of others (at least 17) round the Cape Peninsula and elsewhere.

#### (*a*) Pilchards (*Sardinops ocellata*).

Pilchards occurred in 89 (35 per cent) of all stomachs examined during 1954–56. They com-

prised 51 per cent by weight of all food. They were 94 per cent by weight (or volume) of food taken in August but only five per cent of that taken in December. They were the chief prey in the investigational area for nine months of the year, including the winter months of June and July when the fish are thought to move elsewhere round the coast (e.g. to Natal).

The greatest weight of pilchard in any stomach was 652 gm., for six fish caught in St. Helena Bay. The mean weight from all stomachs, however, was only 171 gm. The greatest weight of pilchards was taken in August.

The highest number of pilchards in any stomach was 23 (length 8 cm.). Fifty-five gannets had taken 191 fish, a mean of four per stomach. Of 51 stomachs with pilchards, 38 (75 per cent) had between zero and five pilchards each, 11 from six to ten, and 1 from eleven to sixteen. Only one of these stomachs had more than 20 pilchards. In March, 1956, a gannet took nine pilchards (weight 605 gm.) of commercial size from a damaged lampara net cast near Seal Island in False Bay (there is a record of a gannet regurgitating eleven large pilchards on Possession Island). Of the 191 pilchards that could be measured accurately—

59 (30 per cent) were in the 5–10 cm. length group; 11 (6 per cent) were in the 11–15 cm. length group; 64 (33 per cent) were in the 16–20 cm. length group; 42 (22 per cent) were in the 21–25 cm. length group; 15 (9 per cent) were in the 26–30 cm. length group.

Thirty-one per cent of pilchards eaten by gannets were over 20 cm. long. Pilchards of less than 5 cm. are seldom, if ever, taken by the gannets.

Pilchards appeared in stomachs collected in June (20) and September (14). The consumption of pilchards was heaviest (27 per cent) in the Walker Bay area, less so round the Cape Peninsula (22 per cent) and Dassen Island (23 per cent). It is probable, however, that similar prey is taken to much the same extent everywhere in the investigational area.

Pilchards of small size (5–10 cm.) were taken in April, May and July. Many stomachs contained pilchards only (see Table 16), but these fish were found with cephalopods and maasbankers more often than with anchovies, sandeels or skippers; 357 pilchards caught by the gannets each averaged 39 gm. weight. The average weight of individual pilchards caught during each of the three years 1954–56, was 33·4, 69·4 and 43·1 gm., respectively. These weights correspond to pilchards of lengths about 14–17 cm.

(*b*) **Maasbankers** (*Trachurus trachurus*).

Maasbankers formed 20 per cent by weight of food in 257 stomachs of gannets shot at sea during 1954–56 (see Table 13). They occurred in 43 (20 per cent) of the 222 stomachs containing food items weighing more than 20 gm. (17 per cent of all stomachs). Their significance in relation to pilchards and anchovies is seen in the following table giving the percentage occurrence, i.e. the number of stomachs with the particular fish as a percentage of all stomachs collected:—

| Year. | Pilchards. | Maas-bankers. | Anchovies. |
|---|---|---|---|
| | (Per cent.) | (Per cent.) | (Per cent.) |
| 1954..... | 33 | 4 | 18 |
| 1955..... | 34 | 45 | 12 |
| 1956..... | 38 | 16 | 7 |

Maasbankers were taken by more gannets in 1955 than at other times during the investigation and it was only in that year that they were more important than pilchards. More gannets had eaten maasbankers during March, April, June and November than in other months. There was, however, no very great difference in the number of birds eating this fish each month; 70 per cent of the maasbankers were consumed round the Cape Peninsula, 5 per cent in the St. Helena Bay area. Maasbankers were taken more often alone than with pilchards or cephalopods and even more so than with anchovies and sandeels (see Table 17).

An average of 12 maasbankers was found in 35 stomachs with this fish. The highest number was 54 (length 5 cm.) in one stomach but single fish measuring 16 and 17 cm. were found in two stomachs. Out of 28 stomachs in which maasbankers could be counted accurately, 12 (54 per cent) had from zero to five fish, 8 (29 per cent) from six to ten fish.

The maasbankers from 34 stomachs fell into the following length categories:—

18 per cent were in the 0–5 cm. length bracket.
62 per cent were in the 6–10 cm. length bracket.
17 per cent were in the 11–15 cm. length bracket.
1·5 per cent were in the 16–20 cm. length bracket.
1·5 per cent were in the 21–25 cm. length bracket.

Fourteen stomachs collected in 1956 contained 85 maasbankers weighing 1,918 gm. or an average of 22 gm. for each fish.

(*c*) **Anchovies** (*Engraulis japonicus*).

Anchovies were 12 per cent by weight of all food. Traces were found in 33 out of the 257 stomachs. On the basis of occurrence in all stomachs they were 13 per cent but only 6 per cent in the case of stomachs with food weighing more than 20 gm.

The largest number of anchovies appeared in June and October in single stomachs as well as in the collection as a whole (16 out of the 33 stomachs); 51 per cent of anchovies were consumed on the West coast between Table Bay and Saldanha Bay. There were 319 anchovies in 22 stomachs or an average of 15 per stomach. The highest number of anchovies in any stomach was 54 for fish measuring 5 cm. long. There were 52 anchovies measuring about 12 cm. long in another stomach. The smallest anchovies (*circa* 5 cm.) were taken in March and April. No fish were under 5 cm. but ranged up to 13 cm. long.

The weight of anchovies in single stomachs never exceeded 186 gm. (twelve fish). Anchovies appeared with cephalopods more often than with other prey.

(*d*) **Mackerel** (*Scomber japonicus*).

Mackerel occurred in 18 stomachs, being seven per cent of all stomachs, or eight per cent of those with food weighing more than 20 gm. They formed five per cent by weight of all food.

They were found in stomachs collected during the mid-winter (June/July) and mid-summer (November/December). Fifty-one mackerel were counted in 15 stomachs, an average of four per stomach. The largest number in one stomach was 33 (length 10 cm.). Both the largest mackerel (length 36 cm.) and the smallest (8 cm.) were taken in June.

(*e*) **Skipper** (*Scomberesox saurus*).

Skipper (or garfish) occurred in seven stomachs (3 per cent) and constituted three per cent by weight of food. They were not reported from gannets feeding in St. Helena Bay, but during hunting nine miles west of Slangkop in January, 1955, personnel of the patrol-boat *Schipa* captured five gannets, all containing skippers (an average of 3·8 fish per bird). Nineteen of these fish weighed 1,000 gm. Squid and pilchards were also found in these stomachs (extracted from unpublished records of the Division of Fisheries).

All skippers were of relatively large size (16–35 cm.). There were 13 fish in five stomachs, a mean of three per stomach. The fish were caught in February, March, September and October.

(*f*) **Sandeels** (*Ammodytes capensis*).

Sandeels occurred in 12 stomachs (5 per cent) and their weight was three per cent of all food taken by the gannets. They were not reported from gannets feeding in St. Helena Bay.

These fish were taken in June, July, September (when they were spawning) through to December. In November they formed thirteen per cent by weight of all food for that month (see Table 12). Sixty-two sandeels were counted in seven stomachs, a mean of nine per stomach. All the fish varied in size from 8 to 15 cm. The largest number in any stomach was 21 (length 12 cm.), taken by a solitary gannet feeding off a surface shoal in Camps Bay.

(*g*) **Harders** (*Liza ramada*).

The stomach of an immature gannet from Table Bay (off the Woodstock Beach) contained 18 harders weighing 280 gm. No harders were found in other stomachs. The species is only preyed upon in a few instances by gannets venturing close to the shore.

(*h*) **Other fish.**

Remains of the following fish occurred in single stomachs:—

| Species. | Time. | Place. | Number. |
|---|---|---|---|
| *Hyporhamphis*.. | June..... | Table Bay.. | 1 |
| *Hemirhamphis*.. | December. | Slangkop.. | 1 |
| *Trigla*..... | July..... | False Bay.. | 1 |
| *Hypacanthus*... | October... | Table Bay. | 4 |
| *Thyrsites*..... | February.. | False Bay.. | 1 |
| *Merluccius*..... | November. | Saldanha Bay | 1 |

Sparid and clupeid remains that could not be positively identified were found in 42 stomachs. Their identification may well extend the number of species preyed upon by the gannet.

Fish bait (pilchards) was taken on several occasions from lines set for snoek or other large fish, or discarded by the fishermen. The diagonally-cut

pieces of fish could readily be identified as bait, not independent prey.

#### (ii) Cephalopods.

Traces of 169 cephalopods were found in 50 (19 per cent) stomachs but their weight was only two per cent of all food. They were almost all squid. In one instance, a pink squid (? *Loligo*) taken in May, weighed 76 gm. and measured 17 cm. along the edge of the mantle. The highest number of cephalopods (beaks) in any stomach was 32, the average from 50 stomachs being three. Fresh meals of squid, e.g. 452 gm. for three squid, were equal in amount to fish prey.

No cephalopods were eaten in St. Helena Bay although gannets had taken them between Cape Columbine and Table Bay.

#### (iii) Crustaceans.

A variety of crustaceans were found in the gannet stomachs. Few of these, however, had been deliberately taken as prey, coming mostly from the stomachs of larger fish prey. The different species of crustaceans belonged to the following families:—

Isopodidae
Euphausiidae *Codonophilus.*
Mysidae *Caligus pelamydis.*
Copepodidae
Stomatopodidae

#### (iv) Polychaetes.

The remains of four polychaetes (*Nereis*) were found in the stomach of a young gannet caught near Camps Bay in April under circumstances suggesting that they had actually been caught by the bird. Polychaetes were also found in an adult gannet from False Bay (August).

#### (v) Miscellaneous items.

Gravel, seaweed, feathers, slivers of wood, liquid and larval nematodes (*Anisakis* and *Contracaecum*) were also found in the collection of stomachs.

The degree of nematode infestation varied and 58 per cent of stomachs were heavily infested in October, less (29 per cent) in July, 1954. In 1955 no nemtodes were found in stomachs collected in April or June.

#### (vi) Interpretation of comminuted matter.

Otoliths, cephalopod pens and occasional polychaete claws were among debris in the stomachs. Much of this could not be interpreted.

Because fish are swallowed head first, many otoliths are released soon after capture of the prey. Some otoliths remain in the stomach for a long time. Thus a bird shot at 0855 SAST had just taken six anchovies but its stomach also contained 20 otoliths probably from prey of the previous day. Another bird shot at the same time had 12 otoliths but no other food traces.

The bulk of squid beaks were in stomachs collected between 0800 and 0900 SAST, suggesting that the squid had been taken the previous day and the beaks not disturbed for 12 hours.

Pilchard stomachs persisted long after other flesh had been digested.

### 9. Feeding Habits.

#### (i) Feeding range.

Gannets do not leave the islands before sunrise, and if returning there, attempt to gain the land at sunset. Very few birds come to roost after dark. Sunrise varies from 0530 SAST in December to 0730 SAST in late June. The sun sets about 2000 SAST in December but much earlier (1744 SAST) in June. The seasonal variation in the number of daylight hours restricts the normal activities of the gannet from 15 to 12 hours daily. An eventual loss of nearly two and a half hours of potential hunting takes place in the winter when the birds no longer feed chicks or fast for long periods.

Flying gannets are reputed to have a cruising speed of 48 m.p.h. (Meinertzhagen, 1955). Travelling before the wind they can cover about 50 miles an hour. Within two hours of leaving say, Malagas Island, the gannets could reach Cape Point. During the summer (15 hours of daylight each day) gannets have nearly 11 hours in which to seek food and return to their nests the same day after flying to remote places. It is doubtful whether they require so much time to find food. Thus in the whole collection of 257 stomachs, only five had less than 20 gm. food after 1600 SAST. Of these five birds, one was suspected to have regurgitated before capture, three had traces of food showing that they had eaten the same day; the

fifth bird had 48 cc. fluid in its stomach. As described elsewhere in this report, gannets are continually moving to and from a nesting colony during the day and seldom take advantage of the theoretically wide foraging-time even under optimum weather conditions. In other words, they feed until they have taken enough, after which they either return to the islands or roost on the surface of the sea.

During the breeding season, gannets fly well beyond the northern and southern limits of the search areas of 1954–56. These limits were 150 miles south of Malagas Island and 210 miles south of Lambert's Bay. Furthermore, rings have been recovered from adult gannets during the breeding season as follows (Ashton, 1950–57):—

| Place of Recovery. | Month. | Approximate distance from Malagas Island. |
|---|---|---|
| | | (Miles.) |
| Cape Point..... | August..... | 83 |
| Lusikisiki*..... | November... | 800 |
| Cape Point..... | December.... | 83 |
| Strandfontein..... | January..... | 100 |
| Mende Point*..... | February.... | 700 |
| Muizenberg..... | March..... | 100 |
| Muizenberg..... | April..... | 100 |

* Recoveries from dead birds that were probably undiscovered for a long time.

These data suggest that gannets from the two western Cape islands range up and down the coastline for at least 150–200 miles when undertaking feeding-journeys during the breeding season. This range, of course, is greatly expanded during the winter non-breeding season when adults move at least as far afield as Mossamedes on the West coast and Durban on the East.

#### (ii) Factors influencing foraging journeys.

##### (*a*) Breeding biology.

Adult gannets loiter about the nesting grounds in August; if paired, they stand together at old nests indulging in mutual courtship behaviour until the egg is laid. These preliminary stages may take two or three weeks but it is not known if the birds abstain from food for so long. They separate for regular feeding spells when incubation commences. Thereafter, nest reliefs regulate the movements of the birds, solitary ones incubating until relieved two or three days later (as far as is known). After the egg is hatched, absenteeism from the nest increases but one or other of the parents nearly always remains with the chick until it is fledged. Guardianship is relaxed to varying degrees in these final stages of the breeding cycle.

The gannet is well adapted to fast during courtship and incubation. Large amounts of yellow fat were detected on the outer wall of the stomach and under the skin of specimens killed during the winter and early spring. Thus, in August a male gannet weighing 2,752 gm. had 106 gm. fat encasing the stomach. Fat weighing 114 gm. was peeled off the stomach of another male gannet weighing 2,892 gm. in the same month. Lesser amounts of fat were on stomachs from July and October. Of 28 specimens with considerable fat on the stomach, 14 had not eaten when captured; five had food weighing under 100 gm.; eight had food weighing between 101 and 200 gm.; and one had food weighing 326 gm.

To sum up: the acquisition of a mate, nesting, incubation and guarding of the chick are activities in the breeding cycle that curtail movement from the land. Far more must be learned about the interrelationship of each phase before we can understand to what extent they influence the duration of the feeding-journeys. It is believed, however, that about 100 days are spent ashore during the seven months of the breeding cycle.

##### (*b*) Weather.

Gannets seek safety in the face of strong winds and storms. They endeavour to return to the islands or ride out the rough weather in sheltered bays or coves. When they would perhaps otherwise do so, gannets do not forage if the weather is bad. Single birds were seen diving during winds of force 6. Mass feeding did not take place beyond winds of force 4.

Because of the transient nature of storms round the Cape (south-west gales seldom last more than 48 hours; north-west gales about 25 hours), and the fact that the wind decreases 10–15 miles seawards (the frequency of south-east winds is considerably less at sea than on the shores of the Cape Peninsula*), it is doubtful if hunting gannets are seriously affected by inclement weather. Nevertheless it is believed that bad weather may make hunting impossible in local areas by affecting the surface of the sea or movements of the prey.

* " Weather on the Coast of Southern Africa (1943), II."

**(c) Availability of food.**

Shoaling fish move widely but their spawning habits often bring them into specific areas at the appropriate season. The sporadic and as yet rather unpredictable movements of the pilchard (cf. Davies, 1956*b*) affect the commercial catches in St. Helena Bay and influence the whereabouts of birds in this area. However, because of their ability to range widely, gannets captured during 1954–56 had consumed pilchards throughout the year. The non-appearance of these and other small fish in local areas in the winter is apparently of no great concern to the birds.

On the other hand, summer feeding-journeys appear to be governed largely by the need to return to feed a growing chick. Yet to what extent the cumulative food requirements of the adult and chick determine the foraging distances is not fully known Observations suggest that unless food is obtained near a nesting island, eggs or young may be deserted. Adults feeding young have regurgitated fresh or only slightly digested fish, implying that the prey was caught shortly before the birds reached the island. It was found, too, that a high percentage of food is caught in the morning during the spring and summer; from this it appears that the birds do not go far afield.

**(iii) Pattern of feeding.**

Gannets commonly move farther off shore (over ten miles) than the other resident sea-birds of this coast; they are, indeed, the most pelagic of the latter birds and emphasise a clear-cut zonation in their feeding range that is frequently overlooked by observers attempting to justify wholesale predation in bays or inshore areas. In fact, computations of bird abundance by land observers at Stompneus (St. Helena Bay) apparently failed to include numbers of gannets for this reason.

Gannets are highly gregarious at their nesting grounds but scatter widely after leaving the islands. Unlike the Cape cormorant, they never move in massed waves but consort in small groups of from two to eight (highest number 34), their mobility contrasting with the cumbersome flight of the cormorants. Gannets seldom maintain line-ahead formations even in small flights. These features are indicative of a swiftly-moving, widely-despersed pattern of independent hunters, maintaining close liaison with each other.

The gannets usually fly about 25 feet above the sea but vary their altitude constantly so that they skim over the waves or soar high into the air. They fly low in the face of strong winds. During rough weather they shelter near the lee shore of bays or simply ride out the weather by floating on the surface of the sea. Orientation of searching birds is a matter of great interest to fishermen who, in spite of mechanical aids, still rely on bird movement to locate fish.

Large feeding flocks (over 500 individuals) were rarely encountered during 1954–56, the majority of birds feeding singly or in small groups of about 50 individuals. Prey must be exceptionally abundant to permit the gathering of large flocks. Initial diving on discovery of the shoals may disperse the latter before distant birds are able to congregate.

**(iv) Capture of prey.**

Gannets obtain their food by diving from a height onto individual prey. On one occasion only was a gannet feeding while swimming among a shoal of small fish at the surface (in March, 1957, however, gannets were feeding under similar circumstances near Robben Island). Aerial diving after moving prey in a different medium presupposes varying sucess in captures, but these implications could not be analysed during the present investigation.

The diving of gannets over a fish shoal has been described in detail for the Australian gannet (Wodzicki and Robertson, 1955) and is very similar to that observed in the Cape gannet. The bird apparently propels itself underwater by means of wings and feet aided by the momentum of its dive. It relies partly on its own bouyancy to regain the surface.

Many authors note how the gannet repeatedly dives for prey (cf. Hare, 1932), swallowing it under water and then resting on the surface between dives. But the exact technique of seizing the prey is not stated. Cape gannets spear many fish from above. Fisher and Lockley (1954) believe that the Northern gannet attacks fish from below. The marks on fish found in stomachs of Cape gannets show that they are manipulated so that the head reaches the stomach first. A maasbanker was once swallowed tail-first.

Gorged gannets form big groups on the surface after feeding. Davies (1955) believed that the gannets rest there until " digestion has become well advanced, when they begin fishing operations again."

The location of fish shoals and concentration of the gannets happens at any time of the day. At 1600 SAST on 20th June, 1954, shoals of pilchards were breaking the surface about five miles off Kleinmond near Hermanus. No gannets had located them then. In fact, a gannet shot half an hour before had eaten a mackerel and a needlefish. The gannets in the vicinity, however, converged on the shoal which was approaching Cape Hangklip and by 1645 SAST the birds were diving repeatedly. The first two birds shot had empty stomachs, but eight others collected ten minutes later had taken up to five pilchards each. The weight of pilchards devoured by these birds is given in Table 20; this random sample suggests that birds with empty stomachs joined the feeding flock, other with 15 per cent of food still in their stomachs resumed feeding; more than six pilchards were not caught at one meal.

Flocking implies abundant prey and stomachs of birds shot under different conditions appear to confirm this. In Table 21 an average weight of 171·6 gm. was taken from flock feeders but only 32·4 gm. from those feeding alone.

#### (v) Time of feeding.

During the pelagic studies gannets were collected between 0800 and 1800 SAST, i.e. during the daytime only. No birds were encountered and none were seen feeding after sunset. Because of the possibility that gannets have an optimum time in which they feed, the amount of food in stomachs was correlated with the time of capture of the specimens. Thus the number of empty stomachs was expressed as a percentage of all empty stomachs from different times of the day; birds with empty stomachs gradually decreased until the early afternoon.

Furthermore, the amount of food varied considerably during the day. When the mean weight of food in all stomachs was plotted against the time of capture of the birds, there was a steady increase in weight of food per stomach throughout the day. In other words, the gannets gradually filled their stomachs as the day advanced. On the other hand, when we take the percentage weight of food at different hours, there is very little variation in food intake throughout the day. A low percentage intake (8 to 16 per cent) occurs at any time. Experience in the field suggests that instead of a definite trend in intensity, feeding is fortuitous. If gannets reach a plentiful supply of food early in the day, they feed to repletion and either return to the islands or cease feeding. In other circumstances, the birds feed steadily but at a rate commensurate with hunting over a long period.

### 10. Discussion.

#### (i) Resumption of feeding.

Davies (1956) described how he fed five captive gannets on mullets (*Liza*), giving each bird an average of 250 gm. The birds were then killed at hourly intervals. One specimen digested 35 per cent of its food in two hours but another specimen (given twice as much as the other), had only digested 41 per cent of its food in two hours. *Only 50 per cent of the food had left the stomach in three hours.* From this feeding experiment, Davies concluded that two and a half hours would be time enough for digestion to have taken place to leave enough space in the stomach for the start of another meal. From specimens captured at sea, however, it was observed that at least 85 per cent of the stomach contents disappear before feeding is resumed (see Table 20).

#### (ii) Meals.

The concept of a "meal" has been limited to obvious differences in the state of digestion of the food items, the amount of food per meal being based upon that in a similar state of digestion. It was decided not to regard each prey-item as representing a meal although this may well be the case with solitary hunters catching large prey. When food was abundant specimens had eaten to capacity and their stomach contents were a good measure of the recent meal.

By inspection of the prey it could be determined in many cases what fish constituted present or past meals. Table 22 analyses 50 specimens that were feeding or had just completed meals; these stomachs all contained more than 200 gm. of food or over 24 per cent of the statistical maximum (see below). This food was divided into particular meals taken during the day. It was found that *the mean weight of the last meal was* 342·7 *gm.*, the penultimate meal 49 gm. Only one bird had eaten a second meal before 1200 SAST, but eight birds still had traces of the former meal in the afternoon (remains of cephalopod beaks in the morning collection are disregarded).

This pattern of food consumption can be correlated with what is known about feeding tours from the nesting colonies, *viz.*, frequent roosting on land with short journeys during the day. Only about 20 per cent of the gannets had indulged in a second meal during the same day. Some of the latter were individuals which had not succeeded in locating a plentiful supply of prey but which had taken individual fish at wide intervals.

#### (iii) Consumption of food.

Disregarding casual statements that gannets eat their weight of fish every day (Neale–May, 1950), the first authoritative statement about the probable daily consumption of food was made by Davies (1955) namely, that if " a gannet feeds successfully for, say, two-thirds of the year, . . . then 3 lb. of fish will have been eaten every day for 244 days by each bird." This conditional statement is not quite clear, but Davies leaves no doubt in the text of his report that he considered this amount (1,361 gm.) to be eaten by a gannet weighing $4\frac{1}{2}$ lb. (about 2,043 gm.) during ten hours of daylight. In his second report, however, Davies (1956) amends his original calculation of the average capacity (600 gm.) of the gannet to 1,000 gm., and on this basis stated that " during one feeding day, therefore, a gannet will consume approximately 4 lb. of fish."

During the processing of data about food weights from gannets collected at sea during 1954–56, it was soon apparent that high values (over 2 lb.) could not normally be attached to the daily food-intake. A weight of 4 lb. of food per day implies an intake of from 70 to 90 per cent of the body-weight and is not in accord with the food-intake values of other birds of large size. Albritton (1954), for instance, gives the daily intake of pelicans as only 15 per cent of their body-weight, gulls 14 per cent. The voracious American merganser was found to have a consumption of 30·1 per cent of its weight in captivity (White, 1957).

The three-year collection of stomachs had an *arithmetical mean weight of* 115·3 *gm. of food* (standard deviation 139·8). According to Simpson and Roe (1939), six times the standard deviation gives a good approximation of the range of the sample. *The statistical maximum weight of food would then be* 838·8 *gm. or* 1 *lb.* 14 *oz. per day.* In practice, gannets rarely gorge themselves to this extent.

From stomach-content weights, meals exceeded 600 gm. on only two occasions, one of which involved predation of netted fish. *The mean amount of food in fresh meals, however, is about* 350 *gm.* At least 80 per cent of gannets indulge in only one meal per day. It is believed that the average weight of a meal will provide a more correct basis than the average weight of food in stomachs, for computing the daily consumption of food. On these premises, gannets would eat about 13 ounces of food daily.

Computations about the annual consumption of food by the western Cape population (50,000) give results of the following order:—

$$\frac{265 \times 350 \times 50{,}000}{16 \times 28 \times 2{,}000} = \text{about } 5{,}200 \text{ tons.}$$

By adding 20 per cent or about 1,050 tons for gannets eating a second meal, the total annual consumption becomes about 6,250 short tons of miscellaneous marine foods. About 70 per cent or 4,375 tons would be fish of commercial interest.

Gannets consume about 4,375 tons of commercial fish annually over a range of some 20,000 square miles. The amount of food extracted from specific localities is relatively less.

## 11. Conclusions.

The investigation showed that in regard to man's interests, gannets are not entirely detrimental. The long list of food species includes non-economic as well as economic species of fish. Pilchards and maasbankers make up a large part of the diet but predation is of such a widespread nature that destructive feeding habits seldom develop in particular areas.

## 12. Acknowledgements.

I am indebted to Dr. K. Barnard, Mr. C. Nepgen and professor J. L. B. Smith for assistance in identifying some of the smaller fish and crustaceans; to Mr. R. Liversidge for many helpful comments about drafting the report; to Mr. T. Stafford-Smith and Cdr. A. Thomas for permission to use their unpublished data about gannet densities; and to my colleagues of the Division of Fisheries for help in many directions.

## 13. References.


ANDERSON, C. J., 1872.—*Notes on the Birds of Damaraland.* 365 pp. London.

ASHTON, E. H., 1950–57.—*Progress Reports on Bird Ringing*, Ostrich, XXI (2), pp. 106–112 (1950); XXIII (I), pp. 56–61 (1952); XXV (1), pp. 2–12 (1954); XXVII (1), pp. 5–13 (1956); XXVIII (2), pp. 98–115 (1957). Cape Town.

BROEKHUYSEN, G. J. AND R. LIVERSIDGE, 1954.—*Colour Variation in Tail Feathers of the S.A. Gannet.* Ostrich, XXV (1), pp. 19–23. Cape Town.

BROEKHUYSEN, G. J. AND R. LIVERSIDGE, 1956.—*Report on a Visit to Malagas Island.* Mimeographed. 2 pp. Cape Town.

BROEKHUYSEN, G. J. AND G. RUDEBECK, 1951.—*Notes on the Cape Gannet.* Ostrich, XXII (3), pp. 132–9. Cape Town.

CHAPIN, J. P., 1932.—*The Birds of the Belgian Congo.* Bull. Amer. Mus. Nat. Hist., LXV, p. 401. New York.

COURTENAY-LATIMER, M., 1954.—*Investigation on the Cape Gannet.* Ostrich, XXV (3), pp. 106–115. Cape Town.

DAVIES, D. H., 1955.—*The S.A. Pilchard: Bird Predators*, 1953–54. Div. Fish. Invest. Report No. 18, pp. 1–32. Pretoria.

DAVIES, D. H., 1956 (*a*).—*The S.A. Pilchard: Bird Predators*, 1954–55. Div. Fish. Invest. Report No. 23, pp. 1–10. Pretoria.

DAVIES, D. H., 1956 (*b*).—*The S.A. Pilchard: Migration*, 1950–55. Div. Fish. Invest. Report No. 24, pp. 1–52. Pretoria.

EDEN, T. E., 1946.—*In Search of Nitre.* London.

FISHER, J. AND R. M. LOCKLEY, 1954.—*Sea-birds.* New Naturalist. London.

GIBB, J. AND P. H. T. HARTLEY, 1957.—*Bird Foods and Feeding Habits as Subjects for Amateur Research.* Brit. Birds, L, pp. 278–91. London.

HARE, H. L., 1932.—*Records of Unusual Habits of Birds.* Ostrich, III (3), pp. 82–90. Pretoria.

HEWITT, J., 1931.—*The Vertebrata Fauna of the Eastern Cape Province.* Grahamstown.

JACKSON, J., 1938.—*The Birds of Kenya Colony.* London.

LAYARD, E. L., 1875.—*The Birds of South Africa.* London.

MACKWORTH-PREAD, C. W. AND C. H. B. GRANT, 1951.—*Birds of Eastern and North Eastern Africa*, Vol 1. London.

MEINERTZHAGEN, R., 1955.—*The Speed and Altitude of Bird Flight.* Ibis, 97, pp. 81–117. London.

MOREAU, R. E., 1950.—*The Breeding Seasons of African Birds: Seabirds.* Ibis, 92, pp. 419–433. London.

NEALE-MAY, W. M., 1950.—*Survey of the South African Fishing Industry with special reference to Fish Meal and Oil.* S.A. Indust. Chemist, 4 (12), pp. 226–230. Pretoria.

PAKENHAM, R. H. W., 1936.—*On the Birds of Zanzibar and Pemba.* Ibis, p. 250. London.

RAND, R. W., 1959.—*The Distribution, Abundance and Feeding Habits of the Cape Fur Seal.* Div. Fish. Invest. Report No. 34, pp. 1—75. Pretoria.

REICHENOW, A., 1900.—*Die Vogel Afrikas.* I. Berlin.

SCLATER, W. L., 1906.—*The Birds of South Africa.* IV. London.

SERLE, W., 1957.—*Contribution to the Ornithology of the Eastern Region of Nigeria.* Ibis, 99, pp. 25–31. London.

SNEYD-TAYLOR, J., 1955.—*A Banding Expedition to Bird Island.* African Wildlife, 9 (1), pp. 25–31. Johannesburg.

WHITE, H. C., 1957.—*Food and Natural History of Mergansers on Salmon Waters of Canada.* Fish. Res. Bd. Canada. Bull. 116, pp. 1–63. Ottawa.

WODZICKI, K. AND F. H. ROBERTSON, 1955.—*Observations on Diving of the Australasian Gannet.* Notornis, 6 (3), pp. 72–76. Sydney.


## 14. Appendix.

TABLE 1.—Co-ordinates and Size of Reference Zones.

| Zone. | Description. | Co-ordinates. | Dimensions.* |
|---|---|---|---|
| 1 | Walker Bay | 34° 38′ S 18° 48′ E<br>shore 19° 20′ E | 350 |
| 2 | False Bay | 34° 30′ S 18° 30′ E<br>shore 18° 48′ E | 350 |
| 3 | Cape Peninsula | 33° 52′ S 18° 16′ E<br>35° 25′ S 18° 30′ E | 200 |
| 4 | Dassen Island | 33° 05′ S Shore<br>33° 52′ S 17° 45′ E | 1,400 |
| 5 | Cape Columbine | 32° 40′ S 17° 40′ E<br>33° 05′ S shore | 300 |
| 6 | St. Helena Bay | 32° 00′ S shore<br>32° 40′ S 18° 00′ E | 650 |

* In square miles.

TABLE 2.—Monthly Age and Sex Composition of 257 Gannets Collected at Sea during 1954–56.

| Month. | Adult Gannets. | | | | | | | Immature Gannets. |
|---|---|---|---|---|---|---|---|---|
| | 1954. | | 1955. | | 1956. | | Unsexed. | |
| | Males. | Females. | Males. | Females. | Males. | Females. | | |
| January | — | — | — | — | — | — | — | — |
| February | — | — | — | — | 9 | 6 | 1 | — |
| March | — | — | — | — | 7 | 10 | — | — |
| April | — | — | 6 | 3 | 6 | 2 | 1 | — |
| May | — | — | 2 | — | 3 | 1 | 1 | 4 |
| June | 17 | 32 | 2 | 5 | 2 | 2 | 1 | 3 |
| July | 7 | 7 | — | — | 8 | 2 | 1 | — |
| August | 7 | 6 | — | — | 5 | 2 | 1 | — |
| September | 3 | 4 | 5 | 2 | 1 | 7 | — | — |
| October | 9 | 3 | 10 | 8 | 2 | — | 1 | — |
| November | 8 | 4 | 2 | 3 | 3 | 2 | — | — |
| December | 2 | 1 | 2 | 2 | 1 | — | — | — |

TABLE 3.—Body Weight in lb. and oz. of Gannets Captured at Sea during 1954–56.

| Month. | Males. | | | | Females. | | | | Mean Weight for Both Sexes. |
|---|---|---|---|---|---|---|---|---|---|
| | Maximum. | Mean. | Minimum. | Number. | Maximum. | Mean. | Minimum. | Number. | |
| | lb. oz. | lb. oz. | lb. oz. | | lb. oz. | lb. oz. | lb. oz. | | lb. oz. |
| April | 6 8 | 6 6 | 5 6 | 2 | 5 15 | 5 15 | 5 15 | 1 | 6 2 |
| May | 6 9 | 6 2 | 5 12 | 2 | — | — | — | — | (6 2) |
| June | 6 10 | 5 14 | 4 8 | 17 | 7 4 | 5 3 | 4 14 | 29 | 5 8 |
| July | 6 0 | 5 9 | 4 10 | 7 | 7 5 | 6 0 | 5 10 | 7 | 5 12 |
| August | 6 6 | 5 12 | 5 3 | 6 | 6 5 | 5 8 | 4 12 | 4 | 5 10 |
| September | 6 8 | 5 14 | 5 7 | 4 | 5 12 | 5 10 | 5 8 | 2 | 5 12 |
| October | 6 5 | 5 9 | 5 7 | 10 | 6 7 | 5 9 | 4 15 | 9 | 5 9 |
| November | 6 5 | 6 0 | 5 5 | 5 | 6 11 | 6 7 | 6 1 | 7 | 6 3 |
| December | 6 0 | 6 0 | 6 0 | 1 | — | — | — | — | (6 0) |

TABLE 4.—Monthly Total of Gannets sighted at Routine Stations of R.S. *Africana II* on the West Coast during 1951–53.

| Month. | Number of observation Days. | Number of Gannets. | | | Total. | Mean. | Number of Gannets at Sea. Observation Day. |
|---|---|---|---|---|---|---|---|
| | | 1951. | 1952. | 1953. | | | |
| January | 8 | — | 401 | 492 | 893 | 446 | 111·6 |
| February | 10 | — | 312 | 548 | 860 | 430 | 86·0 |
| March | 10 | — | — | 122 | 122 | 122 | 12·2 |
| April | 9 | 143 | — | — | 143 | 143 | 15·9 |
| May | 9 | 112 | 1,784 | — | 1,896 | 948 | 210·7 |
| June | 10 | 305 | 122 | — | 427 | 212 | 42·7 |
| July | 5 | — | 989 | — | 989 | 989 | 197·8 |
| August | 10 | 277 | 192 | — | 469 | 234 | 46·9 |
| September | 10 | 65 | 324 | — | 389 | 194 | 38·9 |
| October | 10 | 90 | 202 | — | 292 | 146 | 29·2 |
| November | 9 | 285 | 233 | — | 518 | 259 | 57·5 |
| December | 9 | 231 | 68 | — | 299 | 149 | 33·2 |

TABLE 5.—Number of Gannets sighted at Routine Stations A to T on the West Coast during 1951–53.

| Station. | Distance from Land. | Number of Observations. | Number at Each Station. | Station Total as Percent. of All Sighted. | Average Number per Observation. |
|---|---|---|---|---|---|
| | | | | Per cent. | |
| M | 3 | 20 | 1,266 | | 63·5 |
| P | 4 | 19 | 1,868 | | 98·0 |
| R | 6 | 21 | 1,590 | 80·8 | 75·7 |
| Q | 7 | 15 | 185 | | 12·3 |
| N | 9 | 19 | 795 | | 41·8 |
| H | 14 | 21 | 146 | | 7·0 |
| O | 19 | 21 | 185 | 5·5 | 9·0 |
| I | 20 | 20 | 52 | | 2·6 |
| L | 21 | 20 | 302 | | 15·1 |
| G | 22 | 16 | 95 | 7·1 | 6·0 |
| J | 28 | 21 | 97 | | 4·6 |
| T | 31 | 21 | 17 | | 0·8 |
| F | 33 | 19 | 20 | 1·7 | 1·0 |
| K | 38 | 20 | 84 | | 4·2 |
| E | 42 | 20 | 55 | 1·8 | 2·7 |
| S | 43 | 21 | 71 | | 3·4 |
| D | 56 | 21 | 48 | 0·9 | 2·4 |
| A | 58 | 20 | 17 | | 0·8 |
| B | 67 | 21 | 21 | 0·3 | 1·0 |
| C | 76 | 16 | 15 | 0·2 | 0·9 |

TABLE 6.—Number of Gannets observed on Patrol-boat Cruises during 1956.

| Month. | West Coast, Zones 4, 5, 6. | Cape Peninsula, Zone 3. | South Coast, Zones 1, 2. |
|---|---|---|---|
| | * | * | * |
| January | — | 1+ (4) | 0 (1) |
| February | 5+ (3) | 2 (2) | 9+ (3) |
| March | — | 5+ (3) | 33+ (8) |
| April | 2 (3) | 3 (1) | — |
| May | 1+ (1) | 5+ (4) | 1+ (1) |
| June | — | 5+ (3) | — |
| July | 15+ (5) | 3+ (2) | 1+ (1) |
| August | 4+ (2) | 50 (3) | 21 (2) |
| September | 16+ (4) | 33 (3) | 56 (2) |
| October | 84 (4) | 85+ (4) | 6 (1) |
| November | 48 (3) | 2 (1) | 25 (2) |
| December | 30 (5) | 6 (2) | — |

* Number of cruises in brackets.

Number and plus sign indicates number counted near patrol-boat and others estimated at 50–300 widely dispersed in the vicinity.

TABLE 7.—Occurrence of Empty Stomachs in 257 Gannets collected at Sea during 1954–56.

| Month. | Total Stomachs. | Empty Stomachs. | | | Empty Stomachs as Percent of Monthly Total. | Grams of Food per Ounce of Body Weight. |
|---|---|---|---|---|---|---|
| | | 1954. | 1955. | 1956. | | |
| January | — | — | — | — | — | — |
| February | 16 | — | — | 5 | 31 | — |
| March | 17 | — | — | 4 | 23 | — |
| April | 18 | — | 1 | 6 | 39 | 2·2 |
| May | 11 | — | — | 3 | 27 | 1·4 |
| June | 64 | 23 | 2 | 2 | 42 | 1·6 |
| July | 25 | 6 | — | 1 | 28 | 0·6 |
| August | 21 | 7 | — | 6 | 62 | 0·9 |
| September | 22 | 2 | 2 | 2 | 27 | 2·3 |
| October | 33 | 5 | 6 | — | 34 | 0·7 |
| November | 22 | 1 | — | 1 | 9 | 0·9 |
| December | 8 | — | — | — | 0 | 0·7 |

TABLE 8.—Number of Prey in Stomachs of 257 Gannets collected at Sea during 1954–56.

| Species. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sardinops* | 24 | 14 | 4 | 35 | 58 | 44 | 26 | 28 | 12 | 22 | 5 | 272 |
| *Trachurus* | 5 | 69 | 167 | 4 | 67 | 4 | + | 6 | 12 | 64 | 39 | 437+ |
| *Engraulis* | 0 | 7 | 0 | 5 | 200 | 21 | 0 | 20 | 29 | 43 | 43 | 368 |
| *Scomber* | 0 | 0 | 0 | 0 | 13 | 2 | 0 | 0 | 2 | 34 | 2 | 53 |
| *Ammodytes* | 0 | 5 | 0 | 0 | 15 | 9 | 0 | 21 | 18 | 19 | 2 | 89 |
| *Scomberesox* | 2 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 8 | 0 | 0 | 15 |
| *Etrumeus* | 0 | 0 | 0 | 13 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 15 |
| *Hemirhamphis* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| *Hyporhamphis* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Trigla* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Hypacanthus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 4 |
| *Liza* | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| *Thyrsites* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Merluccius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Unidentified sparids | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| Unidentified clupeids | 0 | 0 | 1 | 1 | 4+ | 0 | 0 | 0 | 1+ | 5 | 0 | 12+ |
| Other unidentified fish | + | 0 | 0 | 0 | + | + | + | 0 | + | 1 | 0 | 1+ |
| Cephalopods | 7 | 3 | 0 | 2 | 11 | 3 | 2 | 1 | 74 | 57 | 9 | 169 |
| Crustaceans | 0 | + | 0 | + | 0 | + | + | + | + | + | 0 | + |
| Polychaetes | 0 | 0 | 4 | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | 4+ |

TABLE 9.—Amount of Food Eaten by Gannets during the Daytime.

| Time of the Day. | Number of Specimens. | Number of Stomachs with more than 20 gm. of Food. | Total Weight of Food. | Mean Weight of Food in. | |
|---|---|---|---|---|---|
| | | | | All Stomachs. | Stomachs with more than 20 gm. of Food. |
| Morning (4 hours) | 143 | 83 | 12,954 | 90 | 156 |
| Afternoon (7 hours) | 114 | 89 | 16,337 | 143 | 184 |

TABLE 10.—Percentage Composition by Weight of all Fish and Cephalopods in Stomachs of 200 Gannets collected at Sea during 1954–56.

| Month. | Number of Stomachs. | Weight of Contents. | Percent. of Fish Prey. | Percent. of Cephalopods. |
|---|---|---|---|---|
| January | — | — | — | — |
| February | 12 | 1,691 | 98 | — |
| March | 16 | 2,567 | 97 | 0·1 |
| April | 13 | 2,089 | 99 | — |
| May | 10 | 1,018 | 91 | 3 |
| June | 45 | 7,644 | 97 | 0·1 |
| July | 20 | 2,391 | 78 | 19 |
| August | 9 | 2,711 | 98 | 0·7 |
| September | 19 | 3,105 | 99 | — |
| October | 27 | 2,676 | 96 | 3 |
| November | 24 | 2,144 | 99 | 0·1 |
| December | 5 | 1,602 | 99 | — |

TABLE 11.—Weight of Food in Stomachs of all (257) Gannets collected during 1954–56.

| Month. | Total Number of Stomachs. | Number of Stomachs with more than 20 gm. of Food. | Number of Stomachs with less than 20 gm. of Food. | Maximum Weight of Food in any Stomach. | Mean Weight of Food per Month for the following Years. | | |
|---|---|---|---|---|---|---|---|
| | | | | | 1954. | 1955. | 1956. |
| January | — | — | — | — | — | — | — |
| February | 16 | 11 | 5 | 360 | — | — | 140·9 |
| March | 17 | 13 | 4 | 605 | — | — | 160·4 |
| April | 18 | 11 | 7 | 375 | — | 186·5 | 102·5 |
| May | 11 | 8 | 3 | 223 | — | 145·5 | 72·6 |
| June | 64 | 27 | 37 | 558 | 171·8 | 188·0 | 89·0 |
| July | 25 | 18 | 7 | 452 | 81·8 | — | 157·3 |
| August | 21 | 8 | 13 | 652 | 347·1 | — | 140·5 |
| September | 22 | 16 | 6 | 456 | 214·2 | 213·1 | 94·3 |
| October | 33 | 22 | 11 | 363 | 118·3 | 80·2 | 149·0 |
| November | 22 | 20 | 2 | 263 | 74·8 | 136·0 | 166·5 |
| December | 8 | 8 | 0 | 581 | 96·4 | 284·0 | 186·0 |

TABLE 12.—Percentage Composition by Weight of certain Fish Prey in Stomachs of 257 Gannets collected at Sea during 1954–56.

| Species. | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sardinops* | — | 67 | 41 | 3 | 72 | 55 | 43 | 94 | 73 | 37 | 26 | 5 |
| *Trachurus* | — | 11 | 40 | 81 | 8 | 10 | 7 | 3 | 14 | 5 | 15 | 46 |
| *Etrumeus* | — | — | — | — | 8 | — | 8 | — | — | — | — | — |
| *Scomber* | — | — | — | — | — | 6 | 8 | — | — | 6 | 11 | 14 |
| *Engraulis* | — | — | 4 | — | 2 | 21 | 6 | — | 6 | 7 | 21 | 30 |
| *Scomberesox* | — | 6 | 11 | — | — | 1 | — | — | — | 21 | — | — |
| *Ammodytes* | — | — | — | — | — | 1 | 1 | — | 5 | 6 | 13 | 3 |

TABLE 13.—Weight of Prey in Stomachs of 257 Gannets collected at Sea during 1954–56.

| Species. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (gm.). | (gm.). | (gm.). | (gm.). | (gm.). | (gm.). | (gm.). | (gm.). | (gm.). | (gm.). | (gm.). | (gm.). |
| *Sardinops* | 1,147 | 1,067 | 66 | 730 | 4,213 | 1,025 | 2,569 | 2,297 | 986 | 554 | 90 | 14,744 |
| *Trachurus* | 290 | 1,037 | 1,710 | 81 | 808 | 179 | 110 | 425 | 135 | 316 | 752 | 5,843 |
| *Engraulis* | — | 111 | — | 25 | 1,655 | 142 | — | 190 | 460 | 461 | 491 | 3,535 |
| *Scomber* | — | — | — | — | 489 | 184 | — | — | 165 | 234 | 221 | 1,293 |
| *Ammodytes* | — | — | — | — | 75 | 32 | — | 174 | 170 | 275 | 40 | 766 |
| *Scomberesox* | 108 | 292 | — | — | — | — | — | 5 | 578 | — | — | 983 |
| *Etrumeus* | — | — | — | 83 | — | 184 | — | — | — | — | — | 267 |
| *Hemirhamphis* | — | — | — | — | 138 | — | — | — | — | — | — | 138 |
| *Hyporhamphis* | — | — | — | — | trace | — | — | — | — | — | — | trace |
| *Trigla* | — | — | — | — | — | 50 | — | — | — | — | — | 50 |
| *Hypacanthus* | — | — | — | — | — | — | — | — | trace | — | — | trace |
| *Liza* | — | — | 280 | — | — | — | — | — | — | — | — | 280 |
| *Thyrsites* | 100 | — | — | — | — | — | — | — | — | — | — | 100 |
| *Merluccius* | — | — | — | — | — | — | — | — | — | 219 | — | 219 |
| Unidentified sparids | — | — | — | — | — | 78 | — | — | — | — | — | 78 |
| Unidentified clupeids | 15 | — | 20 | 6 | 46 | — | — | — | 49 | 25 | — | 171 |
| Other unidentified fish | — | 3 | — | — | trace | trace | — | — | 45 | 16 | — | 64 |
| Cephalopods | — | 3 | — | 76 | 2 | 452 | 20 | trace | 83 | 4 | — | 640 |
| Crustaceans | — | trace | — | trace | — | trace | trace | trace | trace | trace | — | trace |
| Polychaetes | — | — | trace | — | — | — | trace | — | — | — | — | trace |

TABLE 14.—Occurrence of Prey in Stomachs of 257 Gannets collected at Sea during 1954–56.

| Month. | Number of Stomachs. | Stomachs with no Food. | Stomachs with Traces of— | | |
|---|---|---|---|---|---|
| | | | Fish Only. | Fish and Cephalopods | Cephalopods Only. |
| January | — | — | — | — | — |
| February | 16 | 4 | 10 | 2 | 0 |
| March | 17 | 1 | 15 | 0 | 1 |
| April | 18 | 6 | 12 | 0 | 0 |
| May | 11 | 1 | 8 | 2 | 0 |
| June | 64 | 9 | 47 | 6 | 2 |
| July | 25 | 3 | 21 | 0 | 1 |
| August | 21 | 8 | 12 | 1 | 0 |
| September | 22 | 2 | 19 | 0 | 1 |
| October | 33 | 1 | 17 | 12 | 3 |
| November | 22 | 1 | 7 | 14 | 0 |
| December | 8 | 0 | 3 | 5 | 0 |

TABLE 15.—Occurrence of Prey in Stomachs of 257 Gannets collected at Sea during 1954–56.

| Species. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sardinops* | 10 | 5 | 1 | 7 | 19 | 8 | 8 | 14 | 6 | 8 | 3 | 89 |
| *Trachurus* | 2 | 7 | 9 | 1 | 6 | 1 | 1 | 2 | 4 | 7 | 3 | 43 |
| *Engraulis* | — | 1 | — | 1 | 8 | 3 | — | 2 | 8 | 7 | 3 | 33 |
| *Scomber* | — | — | — | — | 11 | 2 | — | — | 1 | 2 | 2 | 18 |
| *Ammodytes* | — | 1 | — | — | 1 | 2 | — | 1 | 3 | 3 | 1 | 12 |
| *Scomberesox* | 1 | 2 | — | — | — | — | — | 1 | 3 | — | — | 7 |
| *Etrumeus* | — | — | — | 1 | — | 2 | — | — | — | — | — | 3 |
| *Hemirhamphis* | — | — | — | — | 2 | — | — | — | — | — | — | 2 |
| *Hyporhamphis* | — | — | — | — | 1 | — | — | — | — | — | — | 1 |
| *Trigla* | — | — | — | — | — | 1 | — | — | — | — | — | 1 |
| *Hypacanthus* | — | — | — | — | — | — | — | — | 1 | — | — | 1 |
| *Liza* | — | — | — | — | — | — | — | — | 1 | — | — | 1 |
| *Thyrsites* | 1 | — | — | — | — | — | — | — | — | — | — | 1 |
| *Merluccius* | — | — | — | — | — | — | — | — | — | 1 | — | 1 |
| Unidentified sparids | — | — | — | — | — | 2 | — | — | — | — | — | 2 |
| Unidentified clupeids | — | — | 1 | 1 | — | 3 | — | — | 1 | 2 | 2 | 10 |
| Other unidentified fish | — | 1 | 1 | — | 1 | 11 | 3 | 6 | 2 | 4 | 1 | 30 |
| Cephalopods | 2 | 1 | — | 2 | 8 | 1 | 1 | 1 | 15 | 14 | 5 | 50 |
| Crustaceans | — | 1 | — | 2 | — | 1 | 1 | 1 | 1 | 3 | — | 10 |
| Polychaetes | — | — | 1 | — | — | — | 1 | — | — | — | — | 2 |

TABLE 16.—Percentage Frequency of Occurrence of Certain Prey in Stomachs of 221 Gannets collected at Sea during 1954–56.

| Prey. | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cephalopods | — | 17 | 6 | 0 | 20 | 14 | 5 | 7 | 5 | 47 | 69 | 62 |
| *Sardinops* | — | 83 | 31 | 8 | 70 | 34 | 36 | 57 | 70 | 19 | 38 | 37 |
| *Trachurus* | — | 17 | 44 | 75 | 10 | 11 | 5 | 7 | 10 | 12 | 34 | 37 |
| *Ammodytes* | — | 0 | 6 | 0 | 0 | 2 | 9 | 0 | 5 | 9 | 14 | 12 |
| *Scomber* | — | 0 | 0 | 0 | 0 | 20 | 9 | 0 | 0 | 3 | 9 | 25 |
| *Scomberesox* | — | 8 | 13 | 0 | 0 | 0 | 0 | 0 | 5 | 9 | 0 | 0 |
| *Engraulis* | — | 0 | 6 | 0 | 10 | 14 | 14 | 0 | 10 | 22 | 34 | 37 |

TABLE 17.—Combinations of Certain Prey in 178 Stomachs of Gannets collected at Sea during 1954–56.

| Species. | *Trachurus.* | *Engraulis.* | *Sardinops.* | Cephalopods. | *Ammodytes.* | *Scomberesox.* | *Scomber.* |
|---|---|---|---|---|---|---|---|
| *Trachurus* | (27) | 4 | 9 | 10 | 5 | 0 | 1 |
| *Engraulis* | 4 | (16) | 4 | 8 | 2 | 0 | 0 |
| *Sardinops* | 9 | 4 | (56) | 10 | 2 | 2 | 3 |
| Cephalopods | 10 | 8 | 10 | (13) | 4 | 1 | 2 |
| *Ammodytes* | 5 | 2 | 2 | 4 | (5) | 0 | 0 |
| *Scomberesox* | 0 | 0 | 2 | 1 | 0 | (5) | 0 |
| *Scomber* | 1 | 0 | 3 | 2 | 0 | 0 | (4) |

TABLE 18.—Amount of Food in Stomachs of 257 Gannets Correlated with Time of their Capture at Sea during 1954–56.

| Time of Capture. | Number of Specimens. | Number with more than 20 gm. Food. | Total Weight of Food in Stomachs. | Maximum Weight of Food. | Mean Weight of Food in All Stomachs. | Mean Weight of Food in Stomachs with more than 20 gm. Food. |
|---|---|---|---|---|---|---|
| 0800–0900 | 27 | 10 | 3,741 | 652 | 138·5 | 374 |
| 0900–1000 | 39 | 17 | 1,966 | 321 | 50·4 | 115 |
| 1000–1100 | 47 | 34 | 4,542 | 282 | 96·6 | 133 |
| 1100–1200 | 30 | 22 | 2,705 | 364 | 90·1 | 122 |
| 1200–1300 | 22 | 16 | 2,634 | 334 | 119·7 | 164·5 |
| 1300–1400 | 35 | 23 | 2,484 | 337 | 70·9 | 108 |
| 1400–1500 | 13 | 12 | 1,988 | 456 | 152·9 | 165·6 |
| 1500–1600 | 20 | 19 | 3,697 | 420 | 184·8 | 194·5 |
| 1600–1700 | 16 | 12 | 3,733 | 558 | 233·4 | 311 |
| 1700–1800 | 6 | 5 | 1,111 | 353 | 185·1 | 222·2 |
| 1800–1900 | 2 | 2 | 690 | 383 | 345·0 | 345 |

TABLE 19.—Surface Temperatures at Time of Capture of Gannets with the Following Prey.

| Prey. | Temperature Range (Centigrade). | | | Number of Stomachs. |
|---|---|---|---|---|
| | Maximum. | Mean. | Minimum. | |
| *Sardinops* | 18·8 | 14·9 | 13·1 | 24 |
| *Trachurus* | 19·3 | 14·8 | 13·6 | 12 |
| *Scomber* | 15·6 | 15·1 | 14·6 | 2 |
| *Scomberesox* | 18·8 | 16·6 | 15·3 | 4 |
| *Engraulis* | 19·2 | 17·3 | 14·9 | 6 |
| *Ammodytes* | 15·0 | 13·6 | 11·0 | 4 |
| *Etrumeus* | 14·0 | 13·9 | 13·8 | 2 |
| *Liza* | 14·8 | 14·8 | 14·8 | 1 |
| Cephalopods | 18·8 | 15·2 | 13·7 | 5 |
| Empty Stomachs | 17·2 | 13·7 | 11·8 | 17 |

TABLE 20.—Numbers and Weights of Pilchards in 8 Gannets collected while Feeding as a Flock off Cape Hangklip at 1700 hours.

| Gannet. | Number, Order of Capture and Weight of Fish. | | | | | | | Total Weight. |
|---|---|---|---|---|---|---|---|---|
| | Penultimate Meal. | | Untimate Meal. | | | | | |
| | | | 1 | 2 | 3 | 4 | 5 | |
| | (gm.) | (gm.) | (gm.) | (gm.) | (gm.) | (gm.) | (gm.) | (gm.) |
| 4032 | 5 | — | 67 | 92 | 99 | 106 | — | 369 |
| 4034 | 13 | — | 101 | 68 | 81 | 125 | — | 388 |
| 4041 | — | — | 99 | 67 | 99 | 105 | — | 370 |
| 4043 | — | — | 81 | 85 | 128 | 155 | — | 449 |
| 4044 | 40 | 30 | 71 | 79 | 81 | 114 | 128 | 543 |
| 4042 | — | — | — | — | — | — | — | — |
| 4036 | — | — | 80 | 89 | — | — | — | 169 |
| 4030 | — | — | 115 | 83 | 77 | 120 | 85 | 480 |

TABLE 21.—Behaviour of Gannets Correlated with the Amount of Food in their Stomachs (1954–56).

| Behaviour when Shot. | Number Shot. | Number with Empty Stomachs. | Weight of Food. | Mean Weight of Food. |
|---|---|---|---|---|
| | | | (gm.) | (gm.) |
| Feeding in flock | 15 | 1 | 2,575 | 171·6 |
| Flying | 33 | 17 | 3,140 | 95·1 |
| Roosting on surface | 37 | 10 | 3,219 | 87·0 |
| Feeding alone | 3 | 2 | 97 | 32·4 |

TABLE 22.—Amount of Food taken at Meals by 50 Gannets collected at Sea during 1954–56.

| Time. | Number of Specimens. | Total Weight of Food. | Mean Weight of Food. | Mean Weight of Ultimate Meal. | Mean Weight of Penultimate Meal. |
|---|---|---|---|---|---|
| | | (gm.) | (gm.) | (gm.) | (gm.) |
| 0800–0900 | 7 | 3,534 | 505 | 502 | — |
| 0900–1000 | 1 | 291 | 291 | 291 | — |
| 1000–1100 | 6 | 1,426 | 237 | 236 | 10 (1)* |
| 1100–1200 | 5 | 1,487 | 297 | 290 | — |
| 1200–1300 | 4 | 1,477 | 368 | 366 | — |
| 1300–1400 | 3 | 815 | 272 | 214 | 68 (2)* |
| 1400–1500 | 4 | 1,437 | 359 | 358 | — |
| 1500–1600 | 5 | 1,578 | 315 | 315 | — |
| 1600–1700 | 3 | 989 | 329 | 329 | — |
| 1700–1800 | 10 | 4,002 | 400 | 380 | 37( 5)* |
| 1800–1900 | 2 | 690 | 345 | 276 | 110 (1)* |

* Number of stomachs in brackets.

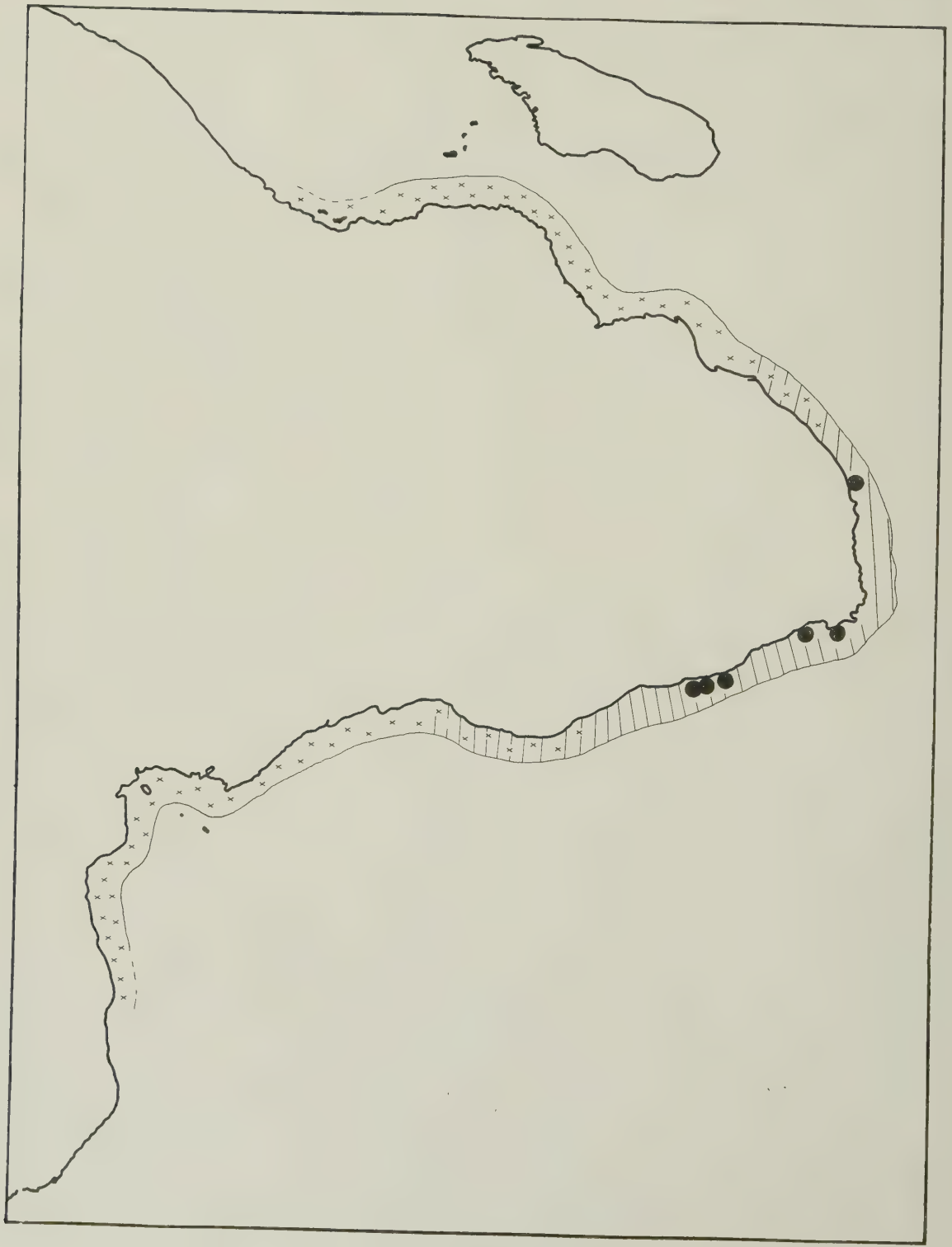

PLATE 1. RANGE OF THE CAPE GANNET.

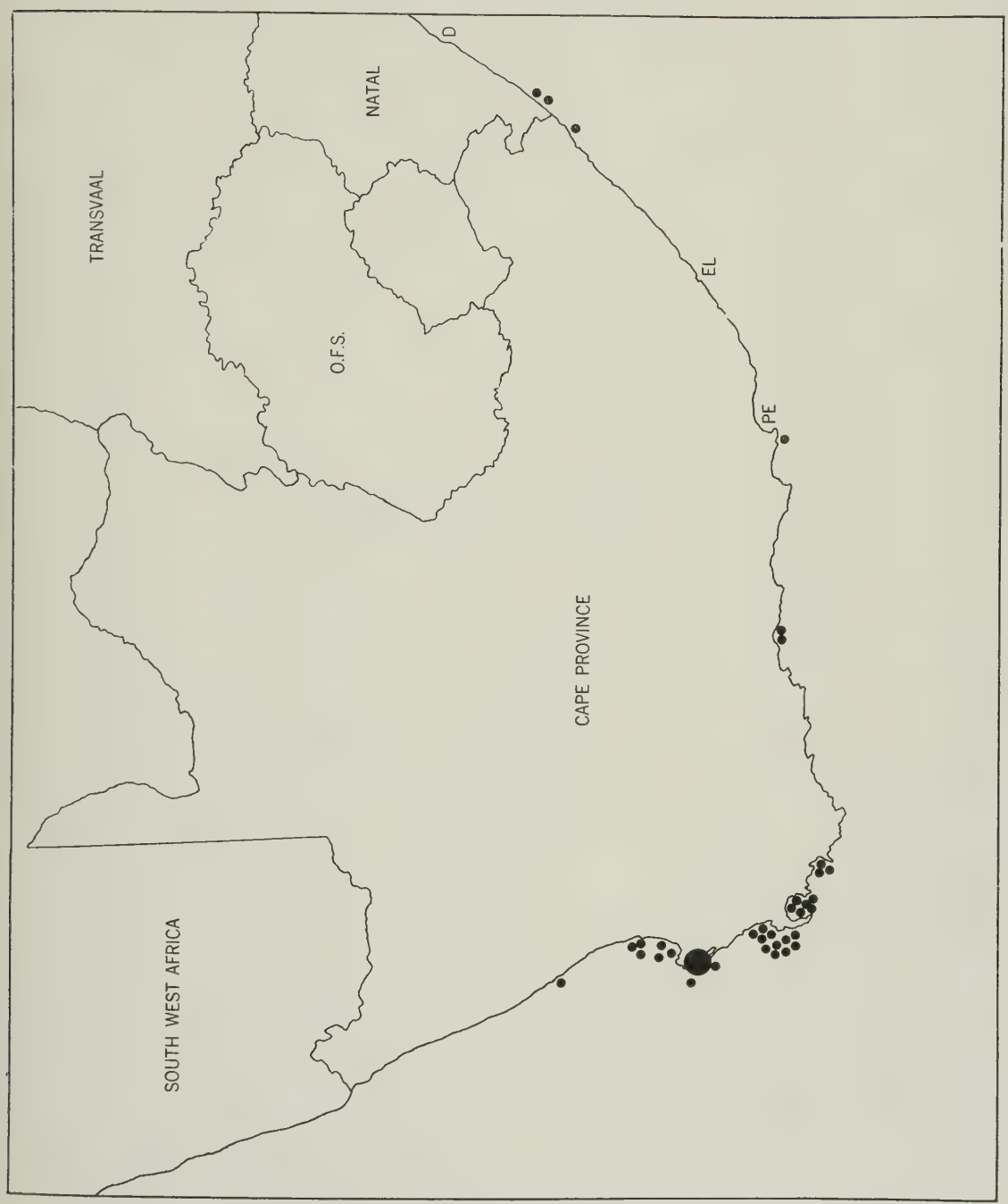


PLATE II. RECOVERY OF RINGED GANNETS.

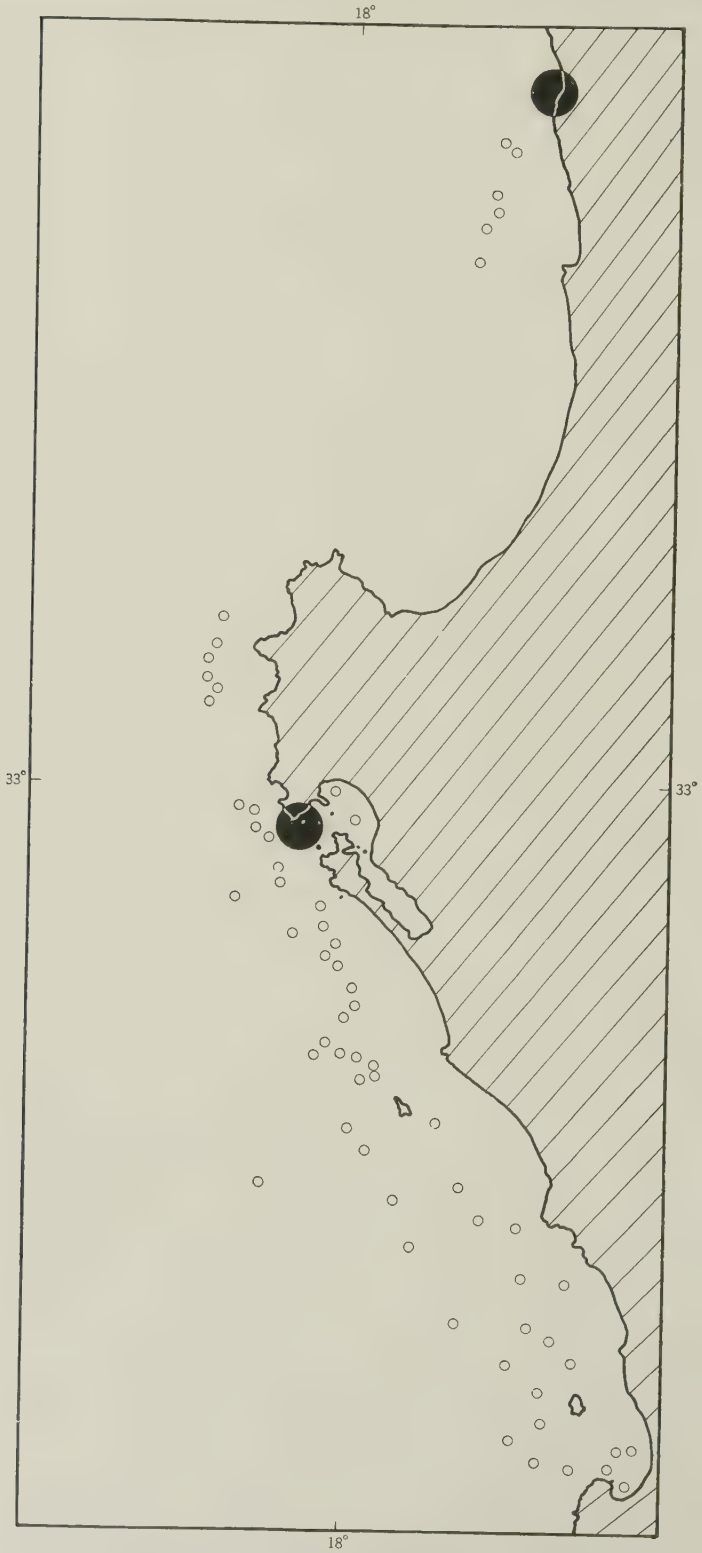


PLATE III. COLLECTION OF SPECIMENS — WEST COAST.

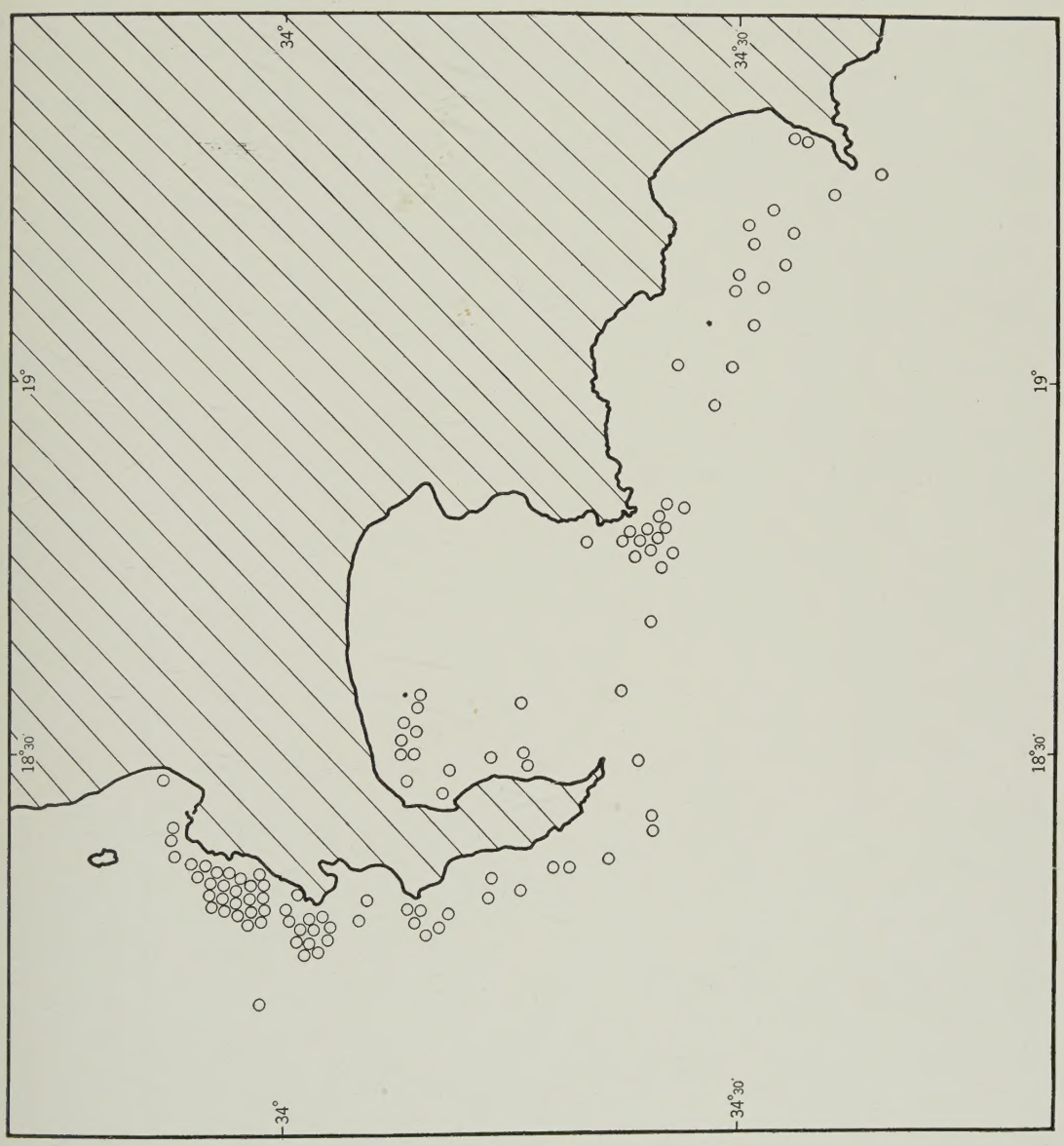


PLATE IV. COLLECTION OF SPECIMENS — SOUTH COAST.

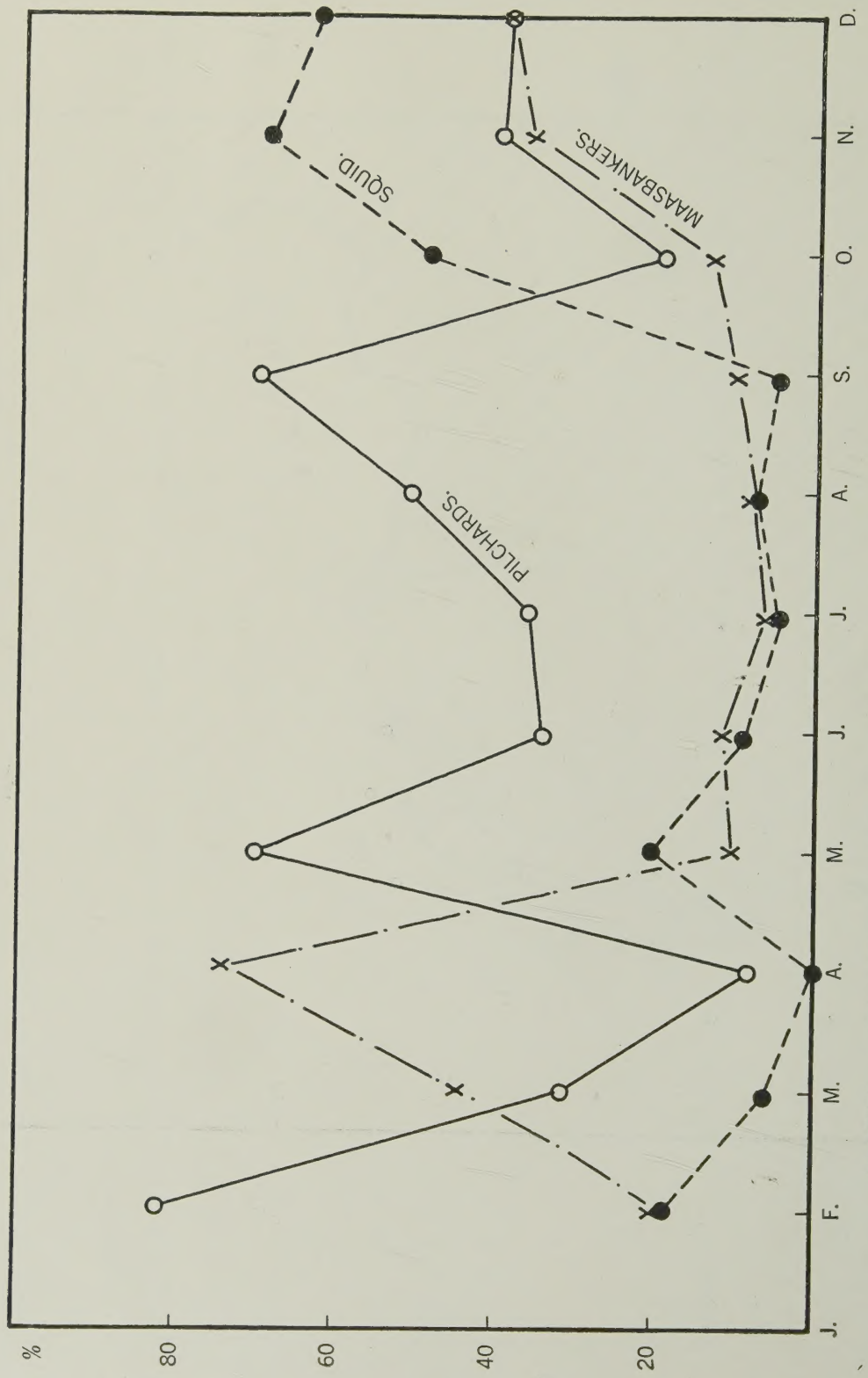


PLATE V. OCCURRENCE OF PILCHARDS, MAASBANKERS AND SQUID THROUGHOUT THE YEAR.